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TRENDS IN PLANT SCIENCE

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THE dawn of the present century may be taken as the beginning of a new epoch in plant science. Farther back than this the impact of science on affairs was indirect and not easily to be appraised. Recognition of the fact that studies of plants from the view-point of the botanist might really concern agriculture, long delayed, came with a rush; the organization of the Bureau of Plant Industry, the members of which devoted attention to special phases of nutrition, cultivation, importation, selection and breeding of crop plants, and in development of methods of protection of cereals, fruits and tubers from the ravages of plant and animal enemies, was accompanied by an increase of personnel from a few dozen to several hundred within two or three years. Similar expansions in state experiment stations followed. Research facilities in universities and colleges were notably increased. The New York Botanical Garden came into full operation: the Desert Laboratory was established, and after thirty-six years of studies on desert vegetation is now concerned with closely related problems in soils and erosion, to which some attention had been given from the first. The publication of the results obtained by hundreds of researchers produced a flood of technical contributions for which new journals were started.

The experimentalist in the field or laboratory as well as the researcher in any branches of science soon found himself at a stage in which words of common usage could not express his findings, with the result that it was necessary to coin new terms. This was the basis of the origin of the much ridiculed "jargon" of science. An article embodying a contribution to science is to be compared with a surveyor's description of a tract of land. The specifications must relate the location, include a calculation, define the boundaries of the area and make its lines close with those of neighboring similarly enclosed areas. Ideally its accuracy must be such that the nearest or next researcher or surveyor can start from these established corners to outline and define the boundaries of unmeasured areas beyond. Such articles are necessary to progress and are written for the guidance of other scientists and may not be capable of expression in common language. Like the field notes of a topographical survey of the Grand Canyon, they make but dull reading for the layman. These and similar writings are in effect a foreign language. They, however, are necessary in placing material facts on record.

Presently it became apparent that the subjects of these unreadable and frankly unliterary papers treated of many things of momentous interest to general welfare. It was in this stage of unfolding science that the war of 1914 opened. In the ensuing mobilization of the industries, scientists were asked to contribute individual expertness, not in finding out new things, but to apply what was known in promoting security and the general

welfare. The botanist turned his attention to the improvement of methods of breeding, cultivation and processing of plants and plant products.

A world-wide appraisal of national and local resources ensued. Personal participation in this survey brought to light the fact that while something like half of the copper in America was produced in the district in which the Desert Laboratory was located the production of food was but 12 per cent. of the needs of the population. The great remainder and most of the power necessary for its industries, farming and mining, were derived from fuel coming across three bridges over the Colorado River, a situation now duplicated with variations in a hundred regions on the map of the world.

The effectiveness of scientific methods applied in war as well as in peace was demonstrated. A general desire for more news about science led to the organization and endowment of Science Service in 1920, and to the addition of science editors to the staffs of many of the more important newspapers. Articles of fair precision dealing with current contributions were given adequate space sometimes on the front page; occasionally the paragrapher indulged in fantastic and startling headlines, but the actual news was available to the reader. The possibilities uncovered so stimulated the imagination of writers in this field, both laymen and technical workers were led into romanticizing current activities and to formulating prophecies, of which only fragments might be ever realized, and a lesser fraction within the span of any living person. This statement must not be taken to place all blame on newspapers and popular writings. Scientists joined in the glorification of contributions from laboratories and observatories, with almost complete disregard of the fact that new ideas recognized as important by a few thousand scientists or by a few hundred thousand intelligent readers may not become practically available to society in its adjustments to the swiftly moving developments in economics of the present day.

Here, as in all the disciplines of knowledge, results must in the first instance be made accessible to workers in the same and in adjacent fields by presentation with exactness, and with some attempt to arrange the new findings in perspective. The obligation to make available the implications of the widened knowledge thus achieved to the economist, the technologist, the sociologist, the statesman and to all forward-looking persons is not less binding. We can not persuade or compel their acceptance; to secure approval and utilization we must make our contributions of such weight, render our interpretations so clear and their pertinence to life so convincing that their adoption will be inevitable.

The originator of a new food product, new fabric or new motor or the statesman who develops an advanced plan of organization or administration does not stop with a simple announcement, but follows it up with continuing explanations and demonstrations of the manner in which the new idea may be utilized to individual and general welfare. The scientist is apt to recount his discoveries to a few colleagues, then toss them out the laboratory window to be picked up, used or abused by accident.

Two important considerations appear in any discussion of the relation of the scientist to the society of which he forms a part. First, it is to be said in repetition of a previous paragraph, that while unceasing efforts to publicize facts newly acquired in the laboratory, to emphasize their importance to the general welfare, or to raise warnings against weakness and dangers in current practices may be made many results of evident value must be available for long periods before they affect current practices. It is pertinent to repeat the trite pronouncement that if every person and all the people would follow definable and practical precautions all the major bodily ailments except

perhaps cancer and colds would dwindle into insignificance.

It was inevitable that cries of "Science is a failure" should have been heard in the economic crises of the last decade. If the scientist will continue to claim that he is "remaking the world" these outbursts are neither unmerited nor unjust. Now that the period of most emphatic censure of science and of scientists for their futility, and in a time when researchers of all kinds are being called from appointed tasks to collaborate in technological plans for the national security, Nobel prize winners, heads of departments in great universities, and research directors of great industries are indulging in optimistic prophecies and forecasts as to the benefits to be expected from current investigations. Pronouncements are shaped up into a ballyhoo, which discounts the possible, painful tedious advances of the next generation, and is an open invitation to the repetition of acrid disappointments which have recently been so freely expressed.

As a further prelude to the discussion of the subject of this article it should be kept in mind that science is essentially nothing more than systematized curiosity. Primarily it means that its devotees continuously seek to widen their knowledge of the world about them, first by simple direct use of their own senses and by experiments, using such tools and apparatus as may be necessary. No serious objection can be raised to this form of learning, and it is widely employed in education. Society has recognized the value of inquisitiveness in promoting culture, advancing civilization and in the development of industries. Laboratories, observatories and experiment stations have been founded, although never to a capacity to meet the full requirements of eager and able investigators.

Adequate or not, the obligation of the scientist is to make highest and greatest possible use of the facilities provided. The experimentalist must realize, however, that the enjoyment of his opportunities does not give him license to blow soap-bubbles. While no restriction can be safely placed on creative thinking, yet the tools of science find their proper function in securing results that will extend knowledge with implied alteration of current generalizations or which will open new vistas.

The following brief sketch of the current activities in laboratories devoted to plant science will serve to illustrate the nature of the problems under investigation. The diligent reader may decide for himself whether or not the facilities, expenditures and opportunities placed at the disposal of botanists, horticulturists, crop disease fighters and plant breeders have been profitably used for widening knowledge and to the economic advantage of society, which has provided them.

The recently observed centennial of the discovery of protoplasm and the recognition of the cell as the unit of living material—both conceptions antedating the recognition of the molecule as an entity—serves to emphasize the fact that at this time when the physicist is successfully concerned with the resolution of the elements into constituent forms of energy or matter, such as electrons, neutrons, protons, mesotrons, the physiologist is taking the living unit apart and variously manipulating its chromosomal particles. Once the elements or units of either living or non-living matter are thus taken apart, not all the king's horses nor all the king's men can put them together again.

There has recently come into the field of the physiologist a form of matter, known as the viruses, with such extraordinary properties and with such dread importance as destructive agents as to make necessary the erection of a new category of organisms. Virus units are now regarded as single large molecules of a proteinaceous structure. These may unite with or break down protoplasm of cells which they permeate readily, but unlike catalysts lose none of

their energy. Propagation is by incitation, not by fission as in protoplasmic action, as the single large molecule may cause the formation of myriad patterns of itself.

The plant pathologist, earlier concerned with the life-histories of fungi and bacteria and protozoa, which affect plants of economic value, now finds himself confronted with the still more serious problem of protecting crops against the ravages of these viruses, which have capacities for infection and damage widely unlike those of any organism previously encountered. Breeding of resistant strains, developments of immunities by methods of cultivation and sterilization of soils, seeds and propagules are practiced. Some of the features by which immunity may be provided by the plant are due to morphological characters, while others rest upon undiscovered or indefinable properties of protoplasm. Development of resistance to the viruses is the most difficult of all problems.

In the four decades following the appearance of Darwin's "Origin of Species," in which biologists indulged in voluminous essays on heredity, descent and evolution, with but little reference to living material, the Weissmanian hypothesis of the unalterable and unchangeable germ-plasm dominated all thinking, and not until experimental methods of study were fully adopted at the close of the century was it possible to escape from its thrall. The mutative departure in lines of descent as uncovered by the researches of the great Dutch botanist DeVries constituted the beginning of modern studies in genetics, the results of which have carried us as far away from that soporific dogma as has the use of the cyclotron from the old conception of "frozen" atoms.

Led by a note by Charles Darwin as to some "fool experiments" he had made in injecting chemicals into leaves with the idea of bringing about morphological alterations the author made some equally crude but successful attempts to modify egg cells by injecting zinc salts into pistils in 1905. Next Gager used radium emanations more exactly administered with more definite results. Many skilled experimenters using various agencies have since induced changes in the nuclear particles or chromosomes, which vary in number from species to species from a few to several dozen. These bodies undergo mitosis, splitting into pairs, the halves uniting with fragments from other units generally with final reductions so that the ultimate cells carry the initial number of chromosomes.

Exposure of cells during mitosis to various agents or unusual conditions of temperature may result in cells with multiples of the initial number of chromosomes, or the loss of some, may slow down the action of some or speed up the action of others, with consequent disjunctions, or may alter the insulating sheath of one so that it may be subject to an unusual disturbance by another. Now these particles are the actual physical bearers of the hereditary qualities, and the offspring arising from such altered chromosome complexes will not be like the parent plant and this unlikeness may be passed on to its descendants. Hybridization entails the union of particles derived from the chromosomes of unlike parents, and this action has long been utilized in securing forms with qualities of greater economic value.

Taxonomy or systematic botany has been for the past century the most completely static branch of botany. Classification of the elements of floras or the plants of newly explored areas and alterations in nomenclature have absorbed most of the energy of the workers in this field.

Species, instead of being regarded as unalterable lines of descent, are known to undergo changes from generation to generation based upon multiplication, loss or disjunction of chromosomes, induced by newly encountered conditions

or complexes of soil, seasonal variations, unusual radiations or animal cooperators. Many hundreds of species of seed-plants are now known which include races or strains with atypic chromosomal characters. The analysis of these and other complexities of genetic constitution promises the surest foundation for advance in studies of speciation and evolutionary derivation as well as for an intelligent procedure in the development of better fruits and grains.

Perhaps no function of plant life exceeds in basic interest the complicated process by which carbon dioxide of the air, water and nutrient salts are drawn in, bonded, compounded and made available to be transformed into living matter and all the complicated tissues and structures of organisms. Directly or indirectly such vegetable material is the food of all animals. The commonest substances of the soil are utilized. It is known that some rarer elements that are drawn up in the sap in minute proportions are necessary, but these, like potassium, magnesium and sodium, are widely distributed and are present wherever vegetation finds a foothold.

The entire process of carbon conversion is chiefly carried on in leaves or tissues containing chlorophyll and is known as photosynthesis. The dissociation of water or of carbon dioxide on catalytic surfaces by energy derived from absorbed light may be regarded as being a plausible generalization as to the nature of the process, yet it is to be admitted that the results do not conform to the pertinent mathematical equation.

The fact that a green plant may carry on the process for limited periods in darkness, and that a colorless flagellate, Chilomonas, has been demonstrated by Mast and Pace to be capable of carbon conversion and accumulation of starch, in a sterile culture of mineral nutrients in darkness and that a common mould, Aspergillus, uses carbon dioxide, suggests that protoplasm may have a fundamental capacity for the necessary catalyses, with whatever low level of energy may be available.

In the group of sulfur bacteria, including several genera and many colorless species, carbon conversion is carried on in darkness by the use of energy derived from the oxidation of hydrogen sulfide, a necessary constituent of their nutritive medium. The purple bacteria of this group carry a greenish "bacteriochlorin" (not related to chlorophyll) and a reddish carotinoid, which absorb energy from light and carry out carbon conversion.

The facts cited justify the inference that while protoplasm has a basic capacity for the assimilation of carbon, the necessary energy may have been derived from many sources in the evolutionary development of plants. that many light screens may have been used and discarded, that the pigments of the purple bacteria is an example of light-absorbent mechanisms, however numerous in the past, are now of limited occurrence, and that the chlorophyll apparatus, the prevailing type of sun-screen, makes available a comparatively enormous amount of radiant energy for carbon conversion in green plants.

That their entire supply of carbohydrates may be synthesized by chlorophylless seed-plants, when their underground parts are associated with fungi to form mycorrhizae has long been known. About two hundred species in the heath, orchid, gentian and triurid families are devoid of green color. Their supply of carbon may be derived from humus products through the cooperating fungi, and the possibility is not excluded that the simpler carbon dioxide may be utilized. All forest trees have mycorrhizal root-systems and derive a considerable share of woody material in this manner. Here as in the case of nitrogen fixation by plants with root-nodules containing a symbiotic rhizobium the possibility that the bonding of this simple and important element may be carried out by the protoplasm of the

higher plant is heightened by the fact that some researches have yielded evidence that nitrogen fixation may be accomplished by seed-plants.

Alteration of perspective to bring basic capacities of living matter into the foreground and development of new instruments and methods of research, including the use of radioactive isotypes, the electron microscope and fresh technique in cytological experimentation, may be expected to rescue the problems in carbon conversion and nitrogen fixation from the stalemate in which they now are found.

Protoplasm has a capacity by which it draws into its mass a wide variety of substances of inducing chemical combinations beyond those implied in photosynthesis and of converting the resulting material into the colloidal state characteristic of living matter. Such accretions are the essential feature of growth. Increase in size has been the subject of innumerable observations. By compilation of measurements of rates of increase a curve has been plotted expressing the fact that in the growth of any unit, any organ or any individual plant or animal the rate is at first low, then quickly rises to a maximum, after which it falls off very gradually. In the case of many perennial plants growth continues during the lifetime of the individual, which may be as long as three thousand years in the big Sequoia of the Sierra Nevada.

The newer researches on growth have been concerned with analysis of the physical conditions which make for the accretions to, depletion or repletion of the protoplast or of its organs, and to a study of the morphogenic procedure by which cells in the latter part of their curve of growth may undergo differentiation into the tissues. So great is the activity in this field that a society has been organized to promote ready communication among the workers engaged and to support a journal for the publication of pertinent contributions. While both zoologists and botanists have conjoined in this movement it is conceded that the generative cells of plants offer the widest variety of opportunities for experimental study.

This last consideration applies with especial force to auxins or growth-promoting and growth-inhibiting substances, vitamines and respiratory ferments, which may originate in one part of the plant and be translocated to another, or which, as in the case of most trees, may be derived from the organic matter in the soil or may be furnished by cooperating fungi with which the roots form a symbiosis as in mycorrhiza.

The action of these substances has been compared to the secretions of the ductless glands of animals with but slight enlightenment. As they are translocated from the region of origin to neighboring tracts much after the manner of other organic material their designation as hormones is also misleading.

The growing points of stems and roots are of primary generative cells, the growth of which results in increase in length. Increase of thickness is produced by the division of growth of secondary generative cells. The two tracts differ in their properties so that the indolic acids simulating "auxins" checks or inhibits the activity of growing points in buds or roots and thus prevents elongation, while cambium or secondary generative cells are stimulated. Growth in length is facilitated by vitamines and by several mineral elements derivable from soils. The conjoint activity of many of these substances is responsible for the orderly precession of organ-formation and for the completion of the processes of differentiation of cells into tissues, such as vessels, tracheids, fibers, sieve cells, cork, etc. Such a well-knit program would result from growth-promoting substances originating with the plant. However, when the roots of long-lived perennials such as trees are furnished growth-promoting substances as usually occurs in mycorrhizae, by fungi

or other organisms in the soil, seasonal growth may be initiated weeks or even months in advance of any possible supply from the shoot.

Some of the tropisms by which stems bend toward or away from sources of radiant energy or in direct or negative response to gravity make the implied curvatures by unequal growth caused by localized formation or accumulation of "auxins." A wide variety of useful practices in culture and development of economic plants has been made possible by researches on growth, as regulated by auxins, vitamines and "trace" mineral elements.

The results cited above may be taken to exemplify the content of thousands of contributions which embody the trend of investigation of the nature and action of organisms. The solutions of the problems obtained afford a basis for a better comprehension of the world of plants and animals and make possible a more intelligent adjustment by man to his place in nature. A material part of this adjustment finds expression in improved methods of agriculture in both plant and animal industries.

About four thousand million acres of land surface may be profitably utilized in agriculture. While the population of the globe has doubled within the last eighty years to a total of well over a thousand million, the application of well-known biological laws makes it highly improbable that there will ever be as many as two thousand million people alive on the earth at any time. Agricultural products year by year and every year have shown a surplus, although local failures of crops have resulted in famines before supplies could be moved into the stricken area.

Application of available knowledge as to growth, breeding and culture could be made to increase the yield two or even three times. Although these facts constitute a guarantee of material security, to be recalled in any attempt to unsnarl tangled economic conditions, their recapitulation by no means includes all the factors to be taken into account. Certain technological activities, political and sociological developments, present a much more complex problem for which an equation has not yet been found.

Only reluctantly will scientists admit that any technological program is not beneficial in all its effects. It is assumed that any new mechanical device or that any new conversion of material to another use is justifiable and contributory to the general welfare. Researchers whose pronouncements in their own fields of investigation are widely accepted will naïvely but boldly allege that new automatic machinery, new processes and all alterations in the use of basic raw materials are immediately beneficial. Nothing could be more fallacious. A new textile, a new alloy or a new plastic may impair the welfare of the inhabitants of regions widely distant. Two or three generations may live out their lives under stress before readjustment is made. "Survival of the fittest" is a fairly benign idea in comparison.

The plant scientist in the laboratory and his collaborators in the experimental field can sustain the plea of not guilty to this lack of comprehension of the serious consequences of diversion of raw materials.

Early in the period during which a rapid increase in population occurred three fourths of everything used or consumed was derived from the fields, forests or from animals supported by them. Despite varied utilization of wastes, with no deficiency even with the enormously increased population, this proportion has now fallen to about one fourth. The products of the coal-fields, oil-wells, quarries, salt deposits and mines are now being drawn upon heavily and processed to meet the requirements of material for tools, implements, machinery, power, textiles, houses, dyes and a vast array of compounds used in food, medicine and the industries. Three

fourths of human wants and needs are met by this material at the present time.

The stores of material thus drawn upon were accumulated in long geological periods, and would be replaceable only by a repetition of the conditions under which they were laid down. Whether these deposits may be exhausted within a hundred or two hundred years is debatable. But presumably, since they are measurable, they are not inexhaustible. In their uncontrolled exploitation, accumulated savings are being used, while possible annual income from the farm and forest are neglected. It is true that much attention has been given to processing of surpluses of organic material such as sugar, starch, wood, cotton, beans, potatoes, fruits, hulls, stems, etc., but the portentous proportionate reduction in the use of farm products prevails.

Greatly contributory to the condition implied are the political conditions which in connection with wars has started movements toward nationalization of industries. The present tendency is to the effect that every country should develop substitutes or find new sources for the raw materials ordinarily received in free commerce from other regions in which they can be produced most readily. In statements as to the adequacy of the replacements carelessness as to qualities and expense is of the commonest occurrence. Conclusions as to the failures of science may sometimes be traced to extravagant and inaccurate claims made by technologists and inventors. As an example it is to be said that since this manuscript was begun a false claim has been made that compounds have been found that may be used successfully in combating malaria instead of quinine, the principal supply of which is now processed in Java. Such a claim is not supported by reliable medical authorities.

Another dangerous delusion as to substitutes for rubber is being widely publicized. A number of plastics have been made in the laboratory which have some of the properties of the plant product. One is made mainly from derivatives of crude oil. A few may be used in motor tires. All are laboratory products. None may be compounded in a factory as economically as plantation rubber. Possession of the formulae for such material is valuable and might mean much for national security. Their production and use for special purposes to which they are better suited than rubber is of course justifiable on fundamental economic grounds. But since the consumption of rubber is steadily increasing at a rate which will soon reach twelve pounds annually per capita it is important that widely distributed sources of supply, as in the case of sugar, be maintained at all times. The areas in which this material may be grown might be extended many times without infringing on land suitable for the production of staple foods. The survey of tracts suitable for rubber in Brazil, Guatemala and elsewhere by the U. S. Department of Agriculture can be applauded as a wise measure although somewhat belated.[1]

Not all the featues of unbalance can be attributed to the blind zeal of technologists, however. It is a well-recognized principle in most industries that over-production should be avoided. No such rational procedure is to be expected in the greatest of all industries, agriculture. For example, with the annual production of cotton at all times adequate to the world's needs, including all con-

[1] The above considerations also apply to guayule, the rubber derived from *Parthenium argentatum*, a small shrub native to northern Mexico and western Texas. A million pounds of raw rubber is turned monthly from wild shrub by factories in Mexico. About ten thousand pounds can be produced daily by the factory which processes plants from an experimental plantation of several thousand acres at Salinas, California. The successful domestication of this plant and the development of strains in which rubber constitutes 21 per cent. of the dry weight of harvested material is a noteworthy agricultural accomplishment. "Emergency rubber" can be secured in one year after germination of seeds and profitable crops in three or four years.

versions, and with millions of bales of surplus stacked in yards and warehouses from the Imperial Valley to South Carolina, in Mexico, Egypt, Mesopotamia, Nigeria, India and elsewhere, heavier plantings are made. Here as in medical science practice of known facts would abolish important economic illness.

The scientist has no power by which he may implement his disapproval of this blundering procedure. By the application of the results of his researches improved strains of many kinds of plants have been selected, bred or imported; varieties suitable for different climates, regions and populations have been selected, and a never-ending fight in protection of crops carried with notable successes, so that there is now and may forever be food and clothing adequate to insure the comfort and welfare of whatever thousands of millions of people are to be supplied. It is only necessary that such material move freely and speedily from the plantation to the consumer. It is to be admitted, however, that these efforts of the scientist, by the results of which famine in any part of the world might easily be averted, have contributed in no small degree to major disturbances in an economic system based in part on barriers to distribution, shortages in manufactured products and the nearness of want. Admission of guilt to such an indictment is accompanied by no feeling of shame. It is to be pleaded in extenuation that the physical standards of living have been raised, the enrichment of culture promoted and a wider awareness of the world about us achieved.

Since research, invention and technology in general is fraught with such serious possibilities, it will be of interest to note the current activities of the plant scientist.

The centennial of the discovery of the cell, as the unit of living matter, finds him deeply engaged in an analysis of its organization; in the study of the interplay of its minute parts by which the hereditary characters of the plant or animal are transmitted from generation to generation with attention to the incidental and experimental combinations or modifications of these characters. The specific influence of the enzymes, vitamines and auxins, and the nature of the viruses are to be determined. The physical procedure by which the ordinary substances of the soil, air and water are drawn into the cell and transformed into the colloidal states of protoplasm are not to be regarded as understood until they are capable of being expressed as mathematical equations the minor factors of which are being diligently sought. The power by which these operations are carried out is derived by oxidation of organic substances the formulae of which are yet to be framed satisfactorily. Still more remote is the fundamental capacity of protoplasm by which bonding in nitrogen and of carbon is carried out in its complex colloidal mechanism. The conversion of both of these all-important but inert elements is increased by supplementary processes in the higher plants. Nitrogen fixation is markedly facilitated by the symbiotic cooperation of a bacterium in root-nodules, while carbon conversion is enormously accelerated when radiant energy is made available by the screening action of chlorophyll or other pigment, the process then being known as photosynthesis. The included reactions present some baffling problems to the physiologist. Since these two phases of activities of plants are vitally necessary to the existence and continuance of life they are due to receive increasing attention from researchers who employ new reagents as their effects become known, the products of the cyclotron as they become available, new angles of approach as they give promise, and new designs in apparatus such as the electron microscope when they enable the inquirer to delve more deeply into the nature, structure and operation of living matter.

MAUPERTUIS, AND THE PRINCIPLE OF LEAST ACTION

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Every action of nature is made along the shortest possible way.—*Leonardo da Vinci.*

THE principle of least action was discovered by Maupertuis in 1744. Three great mathematicians—Euler, Lagrange and Sir William Hamilton—contributed to the development of that principle. By the end of the nineteenth century, it could be said that the whole science of mechanics rested on this same idea. At that time, undreamt-of things lay ahead: relativity and the quantum theory were just around the corner; the mechanics of Newton failed completely within the atom; least action seemed also to fail, and then, by a sudden transformation, became the cornerstone of the new "wave mechanics" which embraces all the old mechanics and the new as well. It is not strange that the principle of least action is sometimes regarded as the greatest generalization in the realm of physical science.

In its technical sense, the term "action" is not recognized by the dictionary or encylopedia. It is foreign to library catalogues. The principle derived from it is known only to a small group of scientific specialists. Clearly, some explanation is needed to reconcile the absence of all general understanding of this subject with the fact of its surpassing importance.

There are three reasons for this strange situation. First, the idea of *action* is difficult to explain, as will, perhaps, be demonstrated in the course of this article. Secondly, the advantages of the principle, as applied to the solution of mechanical problems, were far from obvious. It has taken two hundred years to recognize its possibilities. Thirdly, the mathematical difficulties of proving that action tends towards a minimum, as distinguished from an extremum (either a maximum or a minimum), were for many years incapable of a satisfactory solution.

The author of this principle, Maupertuis, was one of the scientific leaders of the eighteenth century. His own peculiar genius and remarkable energy, combined with a dramatic environment, gave his career a contemporary fame which has seldom been equalled. To-day, he is practically unknown, or is remembered only as an object of ridicule and contempt. If the principle which he discovered has waited overlong for recognition, there is a striking parallel in the fate of the author.

The simplest way to approach the principle of least action is to consider, first, some human traits which do not seem connected with abstract science. In our daily lives, particularly in our work, we strive as far as possible to "save time and energy." The expression is a common one. Let us look at this from a new standpoint: which of the two, energy or time, are we most anxious to save? Are we willing to expend a vast amount of energy, provided that our results are accomplished in a very short time? Or would we rather take an exceedingly long time, provided that the expenditure of energy is sufficiently small? The first calls for great power, or energy per unit of time; the second calls for a great quantity of time per unit of energy. There is no recognized name for the latter concept. We shall call it "rewop"

(pronounced, rew-op). The derivation will be easily recognized since, in a sense, rewop is the opposite of power. All of us have known people who are inclined to be a little rewopful.

If we examine the laws which prevail in the physical world, we find that whenever there is more than one conceivable method of operation, nature follows the one in which the product of the time multiplied by the energy is the least possible amount. Simple as this seems, it is the key to the solution of all mechanical problems. We have expressed it in mathematical form. It is merely another way of saying that nature saves both time and energy, but that she has no preference between the two. Great power or great rewop—it is all the same. She would just as soon save time as energy.

There are many concepts similar to the idea of energy multiplied by time. Momentum is one. It is mass multiplied by velocity. To grasp these concepts is difficult for those who do not deal constantly with such things. On the other hand, it is easy for an engineer to think of momentum. Usually, he will not even care about the mass or the velocity, separately. What he needs is the product of the two, expressed in centimeter-per-second-grams or similar units. He deals with forces; and this is the measure of a force: rate of change of momentum.

Few of us can remember the time when we took our first tottering steps; walking upright, with great care and concentration, on our two legs. Before we could do that, we must have acquired, somewhere in the back of our heads, a very fair idea of momentum.

It is different with energy multiplied by time. We have gotten along quite successfully in the past without this idea; as a consequence, our minds are incapable of fusing energy and time into a single concept. The first step, of course, must be to find a word for this unfamiliar quantity. Unfortunately, it already has a name—action—and no more unsatisfactory name could possibly have been chosen. What are we to think when a million kilowatt-hours of energy delivered in ten minutes is called "action"; and ten kilowatt-hours delivered in a million minutes is likewise called "action,"—and the same amount of action! It was no slight scientific disaster when we missed our chance of calling this quantity "entropy" or "enthalpy" or some other incomprehensible word.

The difficulty of grasping this new, or rather this old, concept which we must now call "action" cannot be exaggerated. One of the two or three books in English which go into this subject thoroughly was written by the great English physicist, E. J. Routh. He states that a function representing action "expresses the whole accumulation of *vis viva.*" He must have known that the whole accumulation of *vis viva* (an obsolete term for kinetic energy) is still nothing more than *vis viva,* or energy; while action is energy multiplied by time.

Was Routh's mistake a mere oversight? If so, it is strange that Heinrich Hertz, the great German physicist, should have made the same blunder. Hertz writes: "It is difficult to see how the summation of energies existing at different times could yield anything more than a *Rechnungsgrösse.*" This is the German word for: an artificial quantity which is perfectly useless except for practice in arithmetic. Notice again the same idea of a summation of energy, when he was really dealing with an accumulation of action. This emphasis, placed on energy, is fatal to an understanding of action. It is a mistake we are prone to make. In our ordinary use of the term "power" we think of energy first and time second, although each has an equal share in this concept. It was for this particular reason that we in-

sisted on the obvious fact that power is not more essential than its own inverse, rewop. Whatever else action may be, it is a partnership of time and energy in which neither can be emphasized a shade more than the other.

For a truly profound insight into this matter, coupled with prophetic vision, we have the words of Thomson (Lord Kelvin) and Tait, written in 1879: "Maupertuis' celebrated principle of *Least Action* has been, even up to the present time, regarded rather as a curious and somewhat perplexing property of motion than as a useful guide in kinetic investigations. We are strongly impressed with the conviction that a much more profound importance will be attached to it, not only in abstract dynamics, but in the theory of several branches of physical science now beginning to receive dynamic explanations."

It is not my purpose to go into the present-day theory of least action. Indeed, the story of Maupertuis, himself, now demands our attention. But before leaving the scientific phase which is inseparable from the biographical, some account must be given of how this remarkable prophecy of Thomson and Tait has been borne out in the new quantum theory.

Planck discovered that radiant energy (light, heat, and electricity) seems to travel in little units, or packets, of energy, called "quantums." Each particular radiation has its own rate of vibration,—so many cycles or kilocycles per second. The energy in a quantum is not the same for waves of different frequency, but if we multiply the energy in a quantum by the corresponding time it takes for one complete vibration, the surprising fact is disclosed that in every case the resulting action is the same amount. This definite quantity is 26-zeros-65420 erg-seconds of action; or 39-zeros-1817 kilowatt-hour-seconds. It is called Planck's constant.

Heretofore, we may have been haunted by the idea that there is something artificial, something unreal, about the concept of action. Planck's constant is the crowning proof that Maupertuis's discovery pertained to something universal and everlasting. The fundamental nature of this concept is further attested by the fact that action is not relative. It is one of the few quantities which was left untouched by Einstein's Theory.

We come, now, to the man, himself: Pierre Louis Moreau de Maupertuis was born in Saint-Malo, in 1698. Coming from a family of wealth and position, he was able at an early age to devote himself to the study of science. At the age of twenty-five he was admitted to the Paris Academy of Science, chiefly by reason of original work in mathematics. He went to London, in 1728, the year Newton died, and became a member of the Royal Society. Thereafter, he became an ardent supporter of the Newtonian theory of gravitation, which was violently opposed in France, where the ideas of Descartes were considered invincible.

In 1730, Voltaire wrote a letter to Maupertuis, full of the lavish compliments of the period; praising his scientific achievements, and asking for Maupertuis's confirmation of Newton's theory. Afterwards, the two met and were friends for twenty years; together they were responsible for the final acceptance, in France, of the Newtonian theory. Maupertuis was appointed by the King of France to lead a scientific expedition to Lapland, where he measured an arc of the meridian for the purpose of proving that the earth is flattened at the poles, as Newton had predicted.

I have made little attempt to show the color and romance of a career which had already acquired unusual interest. I now approach a drama as strange as any in the annals of science. Two of the characters have already been introduced; the third was Frederick the Great of

Prussia; and the fourth was Samuel Koenig, professor of mathematics, a native of Switzerland.

Upon Voltaire's recommendation, Frederick the Great invited Maupertuis to take the office of president of the new Berlin Academy of Science. Maupertuis accepted the offer and went to Berlin in 1740. Four years later, he published his first account of the principle of least action.

It is significant to find that his discovery was made in connection with the theory of light, and was later applied to mechanics. Years afterward, Sir William Hamilton, recognizing the analogy between light and mechanics, developed in a brilliant manner the mathematical correspondence between the two. His results were not fully appreciated until 1924, when Luis de Broglie published his astounding theory of wave mechanics. Strange to say, Maupertuis—the man who helped to overthrow the Cartesian theory of gravitation—was himself deceived by Descartes's absurd paradox that light travels fastest through the densest medium; and, starting from this wholly erroneous premise, he made his greatest discovery.

In 1746, Maupertuis presented his mechanical theory of least action. Immediately, a controversy arose concerning the new theory, in which Maupertuis found himself opposed by a former friend and fellow student, Samuel Koenig. There were, of course, others who denied the importance and truth of the new theory; Koenig, however, claimed that not only was the theory based on erroneous conceptions, but that Leibnitz had developed the same idea, long before his death, and had communicated it in a letter to Hermann. This letter, according to Koenig, had fallen into the hands of a certain Henzi, from whom Koenig had obtained a copy. He presented a fragment of this copy to the Berlin Academy, and later sent a copy of the entire letter to Maupertuis. Naturally, Maupertuis demanded to know where the original letter could be found, or what evidence there was of the authenticity of this copy; which, if it were genuine, proved conclusively that Leibnitz had anticipated his own discovery.

Unfortunately, Henzi had since had his head cut off, having been convicted of treason to the state; and Hermann had preceded him to another world. Koenig was therefore without witnesses; and was unable to offer any suggestions as to where the original letter might be found. He confined his exertions chiefly to an attempt to prove that the theory was erroneous and without value. Maupertuis then put the matter before the Berlin Academy, and a formal demand was made upon Koenig by the Secretary to produce the original letter or other satisfactory evidence. Months passed, during which searches were made, at the instigation of the Academy and of Frederick, to discover any possible trace of the letter among the papers of Leibnitz, Hermann, or Henzi. Meanwhile, Voltaire took up the quarrel on the side of Koenig.

There are two cardinal points which must be understood in connection with this famous episode. The first is, that Maupertuis's title to fame for the discovery of least action was not even challenged. Had Koenig succeeded in proving the authenticity of his copy, it would not have detracted from the brilliance of Maupertuis's achievement. As he was the first to publish, his place in history is secure. Newton and Leibnitz, for example, both discovered the integral calculus; the two men were therefore of equal genius in this respect. Newton, however, was first to publish, and consequently deserves to be mentioned first in connection with this branch of mathematics. Napier is still the discoverer of logarithms, although the Swiss, Bürgi, made the same discovery at almost the same

time, and published his results six years after Napier.

The second cardinal point is this: From the nature of the circumstances, the burden of proof rested squarely on Koenig. He made the attack. Maupertuis could not by any conceivable form of logic disprove his positive assertion. To do so would be to prove a negative. Consequently, Maupertuis had every right to demand some evidence aside from Koenig's unsupported word. Even though Koenig's chief witness had so completely lost his head, it still rested entirely with Koenig to refrain, or not, from an undertaking which profoundly affected the lives of all concerned, and did irreparable damage to Maupertuis's name.

Six months after the formal demand of the academy was made, no satisfactory reply had been received from Koenig. The academy then published a formal *Exposé* of the affair, signed by all the officers (except Maupertuis) and other members. Koenig was accused of an unjust attack upon Maupertuis's reputation. and it was declared manifest that the copy had been "forged." Koenig resigned voluntarily from the academy.

It may appear that the word "forged" was too strong. It has since led to the greatest confusion, and to make matters worse Maupertuis stressed the fact that the copy of the letter sent to him by Koenig did not agree, in an essential point, with the copy presented to the academy. As it turned out, this has so beclouded the issue in later years as actually to injure Maupertuis's cause.

Any one who has followed the argument thus far will recognize that Koenig was not charged with altering an original document or imitating another's handwriting. The word "forge," as well as the French word from which it is derived, means "to produce or devise that which is untrue or not genuine"; literally, to fabricate in a forge. In this sense, whether justly or not, Koenig was accused of having forged the copy of the Leibnitz letter. It must be evident, however, that even if the copy were genuine, no man of judgment, or with a sense of justice, would have made use of it, in the circumstances.

The facts so far related are easily proved. There are in existence in the United States at least a dozen different volumes, printed at the time, which give the letters which were exchanged, and the arguments on both sides.

Nevertheless, another version of this story has come down through two centuries—a version which owes its origin to Voltaire, and may be called the poet-philosopher version. Thomas Carlyle, in his strange and wonderful "Life of Frederick the Great," added his own unique seal to this account of the affair. In modern times, indeed as late as 1936, Alfred Noyes has given us once again the poet-philosopher version. In his "Voltaire," he writes:

> The younger philosopher, Koenig . . . thought that Maupertuis was mistaken. The principle was untrue, he said, and the idea was not new. Leibnitz had discussed it in a letter of which he had a copy.
>
> Maupertuis, who really does seem to have developed a more than Prussian arrogance, determined to crush the younger man out of existence. . . . He summoned the academicians whose salaries were paid by him. He told them that Koenig had forged a letter by Leibnitz; and on the strength of his presidential position he induced them forthwith to deprive Koenig of his membership of the Academy. . . . At this moment Voltaire quietly lifted his hand and made his own first move. He began by publishing a quiet and courteous letter in defense of Koenig, simply but very clearly describing the act of despotic injustice committed by Maupertuis, and at the same time deftly pricking the bubble of his great discovery.

It is, of course, impossible to reconcile an account such as this with the one previously given. However, we may dismiss with a smile the closing remark about "deftly pricking the bubble of his great discovery." Alfred Noyes, poet, can

hardly be expected to know much about two-hundred years of scientific history, of which most scientists are ignorant. It is difficult, however, to understand why two such cardinal points in favor of Maupertuis as we mentioned earlier escaped his attention—two points which, together, make his cause futile and his logic worthless.

Voltaire's letter was answered by a letter from Frederick, himself, in defense of Maupertuis. Then, in 1752, Maupertuis published his "Lettres" which did not pertain to this quarrel, although there is a reference to it. The Letters were, rather, a collection of various scientific studies intermingled with highly imaginative speculations which were written, perhaps, somewhat in the spirit of H. G. Wells. Some of his ideas have since been brilliantly confirmed; others verged on the absurd. This gave Voltaire his great chance, and he was quick to seize it. In the same year, he published what Noyes calls "the most devastating satire of the century"—the "Diatribe of Doctor Akakia."

Macaulay has said that "of all the intellectual weapons which have ever been wielded by man, the most terrible was the mockery of Voltaire." A perusal of "Doctor Akakia" bears witness to that fact. The full force of this terrible power was directed upon Maupertuis in an unmerciful and unscrupulous deluge of irony.

One of the consequences of "Doctor Akakia" was that Voltaire broke with Frederick and left the court of Berlin, never to return.

There are certain facts which lead one to believe that the much-disputed Leibnitz letter may, indeed, have been authentic. Leibnitz was familiar with the idea of action, as Maupertuis readily acknowledged. Even at that time, the term "action" was criticized as being wholly inadequate, and Maupertuis wrote "that having found this word already established by Leibnitz and by Wolff . . . I have not wished to change the term." According to D'Alembert, it was Wolff who first conceived of action.

Leibnitz apparently made no use of the idea of action, unless it was in an attempt to develop a theory of the conservation of action, similar to the conservation of energy. Many people have tried to prove that he conceived of the idea of least action. None of them support this by actual reference to any of his published works or recognized letters. Within the last few years a French philosopher, after profound study, has come to the conclusion that even if Leibnitz did not actually write the letter presented by Koenig, it was at any rate exactly the kind of a letter he would have written. Henceforth, he refers to this letter as a proved fact. Few of us, however, would be willing to go to this extreme. It seems certain that if Leibnitz did write the Koenig letter he must later have abandoned the idea of least action as unsound.

There is one question concerning this subject which has never yet been adequately answered. What motives led Voltaire to turn with such fury on a friend he had known intimately for twenty years? The violence of his attack seems out of proportion even for the crime of which Maupertuis was conceived guilty. Indeed, Voltaire's ridicule did not entirely cease after the death of Maupertuis, in 1759.

Koenig seems to have been a man of sincerity and high purpose. Voltaire's fame is founded on his love of truth and courage in defense of truth. Carlyle's passion for honesty and justice is the key to his whole character. Noyes has an equal regard for the same everlasting principles. Were they not all, however, deceived into thinking that Maupertuis's discovery was an idiotic piece of nonsense, and hence that he was not entitled to the amenities of civilized warfare?

We turn now to a consideration of more recent times. The present attitude towards Maupertuis, however, can be understood only in the light of this ancient quarrel with Koenig. Voltaire's irony has been more dominant than the supposedly clear and dispassionate record of the scientific historian. The scant mention—if any—which is granted to Maupertuis usually carries with it a faint but unmistakable note of scorn.

A favorite accusation which has been repeated with parrot-like regularity is that Maupertuis was so engrossed in metaphysical speculations that no clear meaning can be attached to his vague and mist-like conclusions. As a matter of fact, he was far in advance of most of his contemporaries in this respect. It would be difficult, for example, to find a more modern or clearer expression of the relation between science and metaphysics than the following words, taken from an English translation of Maupertuis which appeared in 1734. They give also a glimpse of the intellectual pains, long since forgotten, which accompanied the startling idea of universal attraction:

> If bodies still continue to gravitate towards each other, why may we not investigate the Effects of this Gravitation, without diving into the cause of it. Our whole Business will then be to enquire whether or no it be true that Bodies have this Tendency towards each other; and if we find the thing to be a fact, let that content us for our deductions with respect to the Phænomena of Nature; and let us leave it to sublimer Philosophers to search into the Cause of this Tendency. . . . But some of those who reject Attraction, look upon it as a Metaphysical Monster and believe its impossibility so fully proved that however Nature might seem to favor it, it were better to acquiesce in total Ignorance, than to make use of so absurd a Principle.

With regard to least action, Maupertuis makes it perfectly clear that in this case, also, his essential Business is to enquire whether or no it be true.

E. T. Bell once wrote, with regard to a certain algebraic expression, that anyone who could look at it and not be at least mildly surprised must be an "algebraic imbecile." In the same way, one must be a metaphysical moron not to recognize the implications of the principle of least action for a divine Providence with which science, officially, cannot be concerned.

Some such argument as this is necessary to excuse the earlier part of this article where no attempt was made to escape a metaphysical explanation of least action, although care was taken not to spell nature with a capital "N."

A more serious criticism of Maupertuis is that even apart from metaphysics, he had no adequate conception of his own discovery, and that his applications of it were merely trivial. There is, apparently, only one book in English (a translation from the German) which gives an account of the three problems which Maupertuis worked out to illustrate his principle. We refer to Mach's classical "Science of Mechanics." It is far better, if one can do so, to read Maupertuis's own words which give in concise, lucid style his applications of least action to inelastic impact, elastic impact, and the principle of the lever.

If Maupertuis's works are not available, however, Mach's book gives a fairly good outline of these three cases. His conclusions, nevertheless, as to their importance, and as to the importance of least action and Maupertuis's contribution thereto, are entirely wrong. They will ultimately be recognized as the most glaring imperfections in a book which betrays unexpected limitations in more than one respect.

To show how far Mach was from grasping this particular subject, he attempts to belittle the importance of least action by referring to another principle of mechanics which is equally powerful; namely, Hamilton's principle. This principle well deserves to be called after the great Irish mathematician, but it is

an "action" principle. "Hamilton's function" has the dimensions: energy multiplied by time. Hence Mach has merely shown how the principle of least action was in later years to be recast into another and perhaps more significant form.

It is uncommon to find a modern author who recognizes the importance of Maupertuis's analysis. One of the few who have done so is Richtmyer, who writes in his "Introduction to Modern Physics": "Nearly two centuries ago, by a line of reasoning which would have done credit to the Greeks, Maupertuis proposed the law of least action."

There seems to be a general impatience with Maupertuis because he failed to equal his friend, Euler, as a mathematician and could not compete with men who came after him, like Lagrange, Jacobi, and Hamilton. There seems also to be much present confusion about the origin of least action. We read of Euler's principle of least action; of Lagrange's; of Hamilton's; and—perhaps the very latest—of Fermat's principle of least action. Fortunately they are all the same. There is only one, and that is the one of which Maupertuis wrote:

> There is a principle truly universal, from which are derived the laws which control the movement of elastic and inelastic bodies, light, and all corporeal substances; it is that in all the changes which occur in the universe . . . that which is called the quantity "action" is always the least possible amount.

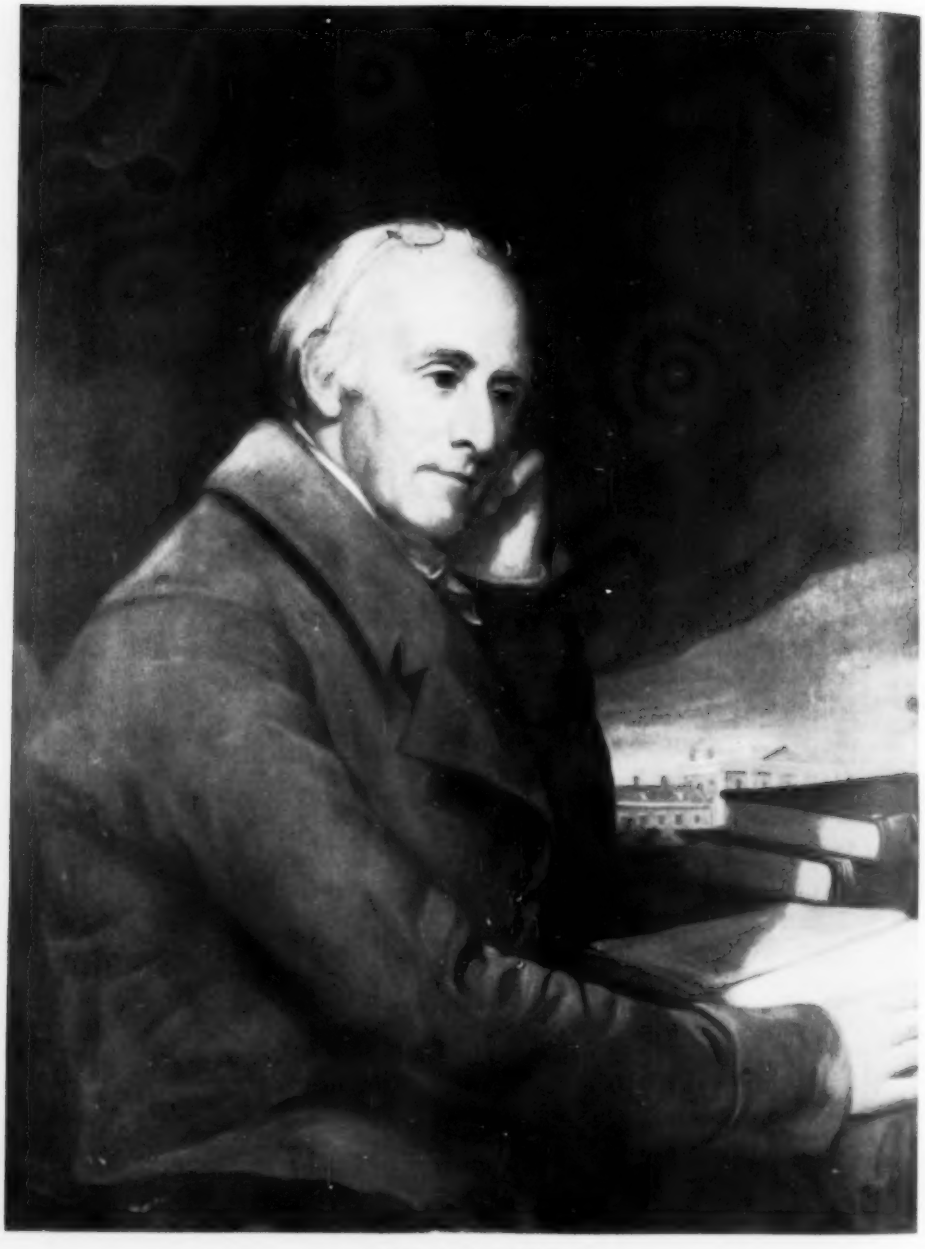
THE ANOPHELES GAMBIAE MOSQUITO IN BRAZIL

THIS dreaded malaria-carrying insect, a native of Africa, was first discovered in Natal in 1930 by a member of the staff of the Foundation. Apparently it had come in an airplane or on one of the fast French destroyers which at that time were serving the French air line between Dakar in West Africa and Natal in Brazil. The alarming spread of this African scourge in northeastern Brazil and the virulent character of the malaria which it produced resulted in a systematic campaign carried on by the personnel of the Foundation in collaboration with the Brazilian Government. Dr. Fred L. Soper, representative of the Foundation in Brazil, has been in charge of the direction and administration of the offensive, and a staff of over two thousand doctors, technicians, scouts, inspectors, guards and laborers have been enlisted in the battle.

A year ago we reported that the gambiae had been pushed back to its central strongholds in the main river valleys and on the narrow coastal shelf of northeastern Brazil—an area of perhaps twelve thousand square miles. Around this area a line of fumigation posts was erected to keep the mosquito from breaking through into new territory, and a concerted advance was begun to narrow still further the boundaries of its domain. The weapons employed were Paris green for potential breeding places and spray insecticides for the fumigation of all buildings.

This intensive campaign in 1940 had dramatic results. During the critical wet season the gambiae was pushed back on all sides, so that by the beginning of the dry season it had been practically restricted to the lower Jaguaribe Valley. This made possible the concentration in this area of a large number of workers for the final onslaught beginning in July. It can now be reported that no larvae or adults of gambiae have been found in the lower Jaguaribe Valley since the first week in September. A small additional focus lying some sixty kilometers beyond the known infested area was discovered in October, but it yielded readily to attack and was apparently clean by the middle of November. No evidence of gambiae in Brazil was found during the last 47 days of 1940.

Those directing the campaign no longer consider it rash to speak of the eradication of gambiae from Brazil, although it must be remembered that the struggle will not be won until the last fertilized female gambiae on this side of the Atlantic is destroyed. In any case, no matter how many isolated foci may yet be uncovered, the critical phase of this immediate campaign seems to be over. Certain mopping-up operations remain to be done as the search is continued for infested areas. The number and extent of these areas should become rapidly apparent with the onset of the rainy season early in 1941.—*The Rockefeller Foundation Report for 1940.*



BENJAMIN RUSH

THE FIRST MAN IN AMERICA TO BEAR THE TITLE PROFESSOR OF CHEMISTRY.

SCIENCE AT AMERICA'S FIRST UNIVERSITY

By CORNELL MARCH DOWLIN

ASSISTANT PROFESSOR OF ENGLISH, UNIVERSITY OF PENNSYLVANIA

THE campus of the University of Pennsylvania, on which was held a goodly portion of the sessions of the ninety-third annual meeting of the American Association for the Advancement of Science, is not notable for its spaciousness. And it seemed especially crowded during a week of September, 1940, when some 250 scholars, learned in the arts, the sciences, the humanities, came from all parts of the world, including embattled Europe, to address nearly 10,000 fellow guests, who were there to help celebrate the two-hundredth anniversary of the founding of the university.

Yet it is not a small campus. All told, the university property in West Philadelphia consists of 112 acres; but some 130 buildings have been erected on the grounds, and they elbow each other closely and adjacent private homes and commercial property. Besides, the buildings are not evenly distributed: included in the campus are eight playing fields, a huge stadium and two large gymnasiums —all devoted to the more or less scientific pursuit of athleticism—and the well-known Botanical Gardens, the most attractive portion of the grounds. Beyond the city limits, the university has more breathing space. In Chestnut Hill, on the northern boundaries of Philadelphia, is the Morris Arboretum, site of a Graduate School of Botany; to the west, along the West Chester Pike, is the Flower Observatory; farther west, at Valley Forge, are two farms, the site of a proposed experimental college of liberal arts; and northeast, near the Delaware River, are farms on which are carried on the activities of a School of Animal Pathology and important investigations (especially in embryology) of the Wistar Institute of Anatomy and Biology.

But into any corner of the present campus might be tucked the acre of ground and the single building at Fourth and Arch streets that served as the first home of the University of Pennsylvania. It was here, in 1740, that the pious people of Philadelphia, especially those interested in the less conservative aspects of religion, erected a large building for the meetings of the celebrated Wesleyan evangelist, George Whitefield, whose welcome in the established churches was not so warm as it had been on his arrival in Philadelphia in 1739. The building was the largest in the city, actually seventy feet by one hundred.[1] Funds to erect it were raised by means of a double-barreled appeal: the "chapel" would serve for religious meetings and also as a charity school. And it is because of the foundation of this school that the university has selected 1740 as the date of its own founding.

Although a board of trustees was organized and some endowment was collected, the charity school languished, and the next important educational step in Philadelphia was the publication in 1749 of Benjamin Franklin's pamphlet, "Proposals Relating to the Education of Youth in Pensilvania." This pamphlet was not a hasty effusion, for Franklin since 1743 had had definite ideas concerning education, and had discussed them with his associates. In their essence, his proposals for an academy were extremely practical. A variety of subjects, ranging from history, government and ethics to law, mercantile practices and even the mechanic arts was to be taught, prin-

[1] A picture of the first campus at about the year 1770 appeared in the December, 1940, issue of the SCIENTIFIC MONTHLY. The building with the belfry was the Whitefield meeting house; the other a dormitory erected in 1762.

THE OLD COLLEGE HALL OCCUPIED BY THE UNIVERSITY IN 1829 AND UNTIL THE UNIVERSITY WAS MOVED TO ITS PRESENT SITE IN 1872.

cipally in English. He did include the classics, but this, as he later pointed out, was to conciliate prominent citizens whose educational ideas were more conservative. The result was the formation of a board of trustees that took over the assets —and the liabilities—of the charity school, and at once started to select a faculty, which began instruction in 1751 in the remodeled chapel at Fourth and Arch streets. The institution was only an academy, however, and the trustees had more ambitious notions. Hardly had it begun to function fully before a new charter was granted, in 1755, incorporating "The Trustees of the College, Academy, and Charitable School of Philadelphia in the Province of Pennsylvania."

The next step in the organization of the Univeristy of Pennsylvania, at least as far as its name is concerned, was far from happy for the young institution. Under its first provost, the Reverend William Smith, the college became closely identified, first during the last years before the Revolution, with the Proprietary party, and then, during the Revolution, with the Tories[2] As a result, in 1779 the Assembly dissolved the old board of trustees and set up another, which was to administer the college under a new name, "The University of the State of Pennsylvania," a proper title because a medical school had been added in 1765. The new trustees, of course, were given possession of all the college property. The action was strongly tinged with politics, and similarly political was the act of the Assembly in 1789, when conservatives had regained power, to restore the old trustees to their property and privileges. The act of 1789 reestablished the college, but it did not extinguish the

[2] One result of the first provost's political activities was his imprisonment in the old jail at Third and Market streets in 1758 for an alleged libel on the provincial Assembly. From February to April of that year he conducted classes in the jail. For this and other details of the history and organization of the University of Pennsylvania, the reader is referred to "A History of the University of Pennsylvania," by E. P. Cheyney, University of Pennsylvania Press, 1940; and "The University of Pennsylvania Today," C. M. Dowlin, ed., University of Pennsylvania Press, 1940.

university; and although Philadelphia could hardly support one institution of higher education, the two continued to function concurrently, the college at Fourth and Arch streets, the ousted university in the building of the American Philosophical Society at Independence Square. But in 1791 reason prevailed, and under a new charter the two united to become the University of Pennsylvania.

The University of Pennsylvania, which thus became America's first educational institution to be called a university, continued at the Fourth and Arch streets location, with some outlying dependencies for the Medical School, until 1802, when, forced out by the encroachments of business establishments, it moved to Ninth and Chestnut streets. Its quarters here were the "Presidential Mansion," a handsome building erected for the use of the President of the United States in the 1790's, when it was expected that the Federal Government would remain permanently in Philadelphia. This building, purchased along with a number of adjoining lots, served as the home of the university until 1829, when it was razed and two buildings, College Hall and Medical Hall, both identical in external appearance and of a pleasing Georgian style, took its place.

By 1870 the Ninth Street location also had become unsatisfactory, and in 1872, following long negotiations with the city for the purchase of ground in West Philadelphia close to the west bank of the Schuylkill River, the College of Liberal Arts moved into a new College Hall. In 1874 the Medical School moved into a new Medical Hall just west of College Hall and also enjoyed the use of the University Hospital, which likewise was erected in 1874. These three buildings, along with a fourth, put up in 1878 to accommodate the Dental School founded in that year, formed the nucleus from which the present extensive plant of the University of Pennsylvania has grown.

But of greater general interest than such legalistic matters as corporate origins, organization and names, and the

COLLEGE HALL, THE FIRST BUILDING ON THE PRESENT CAMPUS
COMPLETED IN 1872. IN THE FOREGROUND IS THE BOYLE STATUE OF BENJAMIN FRANKLIN, WHICH ONCE STOOD BEFORE THE POST OFFICE AT NINTH AND CHESTNUT STREETS, SITE OF THE SECOND CAMPUS OF THE UNIVERSITY.

"PRESIDENTIAL MANSION," AT NINTH AND CHESTNUT STREETS
AND OTHER BUILDINGS OCCUPIED BY THE UNIVERSITY OF PENNSYLVANIA FROM 1806–1829.

early, inadequate physical equipment, is the nature of the institution to which Benjamin Franklin in the middle of the eighteenth century lent his influence if not his name. It will be recalled that in 1748, the year before he began actively to promote the academy, Franklin had retired from business, intending to devote the rest of his life to scientific experiment. Closely associated with him in his investigations were Thomas Hopkinson and Philip Syng, both of whom were members of the original board of trustees set up in 1749. A third associate was Ebenezer Kinnersley, who in 1753 succeeded the first English master

"MEDICAL HALL" OCCUPIED BY UNIVERSITY MEDICAL SCHOOL, 1829–1874
IT ACCOMMODATED AS MANY AS FIVE HUNDRED STUDENTS. "COLLEGE HALL" WHICH ADJOINED "MEDICAL HALL," HOUSED THE COLLEGE OF LIBERAL ARTS.

on the faculty, one David Dove, whose terrible temper figures large in the early annals of education in Philadelphia.

Another name to be mentioned especially in connection with the scientific atmosphere that prevailed from the beginning is that of Dr. William Smith, the stormy first provost. Appointed in 1754 after a long correspondence with Franklin, Dr. Smith became provost in 1755, when the college was established, succeeding the deceased Mr. David Martin, who as head of the academy bore the title of Rector. Provost Smith was engaged to teach logic, rhetoric and natural and moral philosophy, but natural philosophy was his especial interest. A capable mathematician and astronomer, he ably assisted David Rittenhouse during the observation of the transit of Venus in 1769, when the American astronomers placed the earth 20 per cent. farther from the sun by finding the horizontal parallax to be 8.6 seconds. And the second provost, the Reverend John Ewing, had similar talents, especially in engineering. He was very active in establishing state boundaries and in laying out highways. Still another name is that of David Rittenhouse, professor of astronomy and long a trustee, whose accomplishments as a mathematician, physicist and astronomer are too numerous to be recorded here.

Nor should it be thought that this interest in the physical sciences existed principally in the eighteenth century. During the earlier part of the last century a long list of distinguished men held the chair of natural philosophy. Among these were the two Robert Pattersons and John Fries Frazer, the latter a founder and the first president of the Academy of Natural Sciences, an organization intimately associated with the founding in 1848 of the American Association for the Advancement of Science. Worthy of especial mention is a grandson of Benjamin Franklin, Alexander Dallas Bache, an F.R.S. and a voluminous writer on scientific subjects. He was a president of the American Association for the Advancement of Science[3]

THE EVANS INSTITUTE AND SCHOOL OF DENTISTRY, FOUNDED IN 1878

[3] Other members of the faculty who have been president of the association are: George F. Barker, 1879; J. Peter Lesley, 1884; Daniel G. Brinton, 1894; Edward D. Cope, 1896; J. McKeen Cattell, 1924. The last named was appointed to the professorship of psychology at the University of Pennsylvania (the first chair in the world to bear that name) in 1888, but resigned in 1891 to accept the chair at Columbia.

JOHN MORGAN

PROFESSOR OF THE THEORY AND PRACTICE OF PHYSICK IN THE FIRST MEDICAL SCHOOL IN AMERICA. THE PICTURE IS A CONTEMPORARY PORTRAIT BY ANGELA KAUFMAN. IT HANGS IN THE LIBRARY OF THE SCHOOL OF MEDICINE OF THE UNIVERSITY OF PENNSYLVANIA.

and of the National Academy of Sciences, and also was prominent in the work of the Smithsonian Institution, the United States Coastal Survey and the American Philosophical Society.

Although these men taught chemistry as well as physics, chemistry, during the first century of the university's history quite naturally is more particularly associated with holders of the professorship of chemistry, the first chair exclusively devoted to that science to be established in America. This chair was set up in 1769, and its first incumbent was Benjamin Rush, M.D., author of the first chemistry text-book published in America and a man famous especially for his work during the yellow fever epidemics in Philadelphia, but also for a variety of medical interests that would astonish a modern specialist. Although Rush was a member of the medical faculty, not all his successors were primarily interested in the medical aspects of chemistry. Notable among these was Robert Hare, inventor of the oxyhydrogen blowtorch and one of the first to build and operate an electric furnace.

Mention of Benjamin Rush naturally suggests a statement, which must be all too short, concerning the first medical school to be established in America. In 1765, the trustees appointed Dr. John Morgan and Dr. William Shippen, Jr., as the first members of a faculty of medicine. Other appointments followed immediately, and the School of Medicine, of which this was the beginning, soon was attracting students from all English-speaking North America and even from Europe. Indeed, for nearly a century, the College of Liberal Arts remained essentially a local institution, largely because it was a strictly secular school (which may have contributed to the scientific atmosphere) without the support in students and funds that affiliation with a religious denomination would have provided. Its enrolment until the latter half of the last century rarely exceeded one hundred, while the medical students usually were four or five times that number. Space will not permit a recital of the accomplishments of the early School of Medicine, but mention should be made not only of Morgan, Shippen and Rush, but of Samuel P. Griffitts, founder of the United States Pharmacopœia; Caspar Wistar, author of America's first book on anatomy; and of Philip Syng Physick, "father of American surgery."

Until modern times, it must be admitted, the biological sciences as independent of medicine received somewhat scant attention. Although the university claims the distinction of having appointed, in 1789, the first professor of botany and natural history in the United States (Benjamin Smith Barton, pioneer investigator of American flora), botany and zoology as independent studies did not come into their own until 1884, when a School of Biology (now represented by the separate departments of botany and zoology) was founded. It is not the purpose of the present article to comment on the more recent history of the University of Pennsylvania, but three of the principal members of the biological faculty were men of such prominence that they demand attention. They were Joseph Leidy, Edward Drinker Cope and John A. Ryder, men whose work in comparative anatomy, American paleontology and embryology fills a prominent place in the records of the American Association for the Advancement of Science, or more particularly in those of the Academy of Natural Sciences.

It is also to be regretted that something can not be said of other modern developments such as the Towne Scientific School, the Moore School of Electrical Engineering, the Architectural School and the School of Fine Arts, the Wharton School of Finance and Commerce, the College of Liberal Arts for Women, the School of Education, the Graduate School, the Graduate School of Medicine, the Veterinary School, the University Press and the University Museum, the

THE MALONEY CLINIC

ONE OF THE LARGE HOSPITAL BUILDINGS OF THE UNIVERSITY. IT HOUSES A NUMBER OF THE DIVISIONS OF THE SCHOOL OF MEDICINE, INCLUDING THE JOHNSON FOUNDATION FOR RESEARCH IN MEDICAL PHYSICS.

THE "PROVOST'S TOWER"

ONE OF THE DORMITORY BUILDINGS.

latter being a division of the university known and active in the farthest reaches of the world. All the schools or departments just listed have been established since 1875, but in many cases their roots go back to far beyond that date. Another important school not mentioned heretofore is the Law School, the history of which begins in 1790, when the trustees established the first professorship of law in America.

Slight though those roots may have been in the middle of the eighteenth century, when a handful of students was taught by less than a handful of professors, they have grown as the United States has grown, until to-day upwards of 17,000 students receive instruction in almost every branch of learning from a faculty of nearly 2,000 members.

The increase in faculty and students has been accompanied by the increase in physical equipment that already has been noted; but the increase in equipment has not been a change merely in quantity. If subjects and methods of instruction had remained the same during 200 years, classrooms and lecture-rooms similar to those of the old academy at Fourth and Arch streets, but more numerous, would serve to-day. Subjects and methods have changed, however. With the growth of the nation, contributing to that growth and also resulting from it, has come the increased attention paid to the sciences and changes in the equipment needed in education and research.

To cite one example, Theophilus Grew, the first professor of mathematics, doubtless employed few aids other than pencil and paper, protractor and dividers. At present the building of the Moore School of Electrical Engineering contains a sixty-ton apparatus known as a differential analyzer, a complex mechanism of motors, gears, cams and pantographs. Since it was erected in 1935, this machine

has been solving differential equations, providing in one hour a solution that otherwise might require a week of concentrated effort or perhaps could not be obtained at all.

Or to cite another example, in 1749 Benjamin Franklin rigged up two large Leyden jars with which he intended to kill his Christmas turkey, but which very nearly killed him.[4] The apparatus for experiments in natural philosophy in the old college was similar, though probably less powerful, consisting of Leyden jars, electrostatic generators and vacuum pumps. But to-day a part of the equipment of the Department of Physics is a Van de Graaf generator, or "atom smasher," which in effect is a Leyden jar and electrostatic generator capable of creating a charge up to five million volts; and a sixty-inch cyclotron which will develop much greater energy is about to be constructed for the Department of Radiology in the School of Medicine. Such a force, if properly directed, might well alter the course of history—and for the better, if American scientific workers have their way.

Benjamin Franklin and the Social Sciences

To the average layman, the American Association for the Advancement of Science is an organization concerned with the physical sciences or possibly with the biological sciences as well. And yet the association has standing committees on history, education, the social and economic sciences and even (though not at present) on manufactures and commerce. Because of this interest in the social sciences and also because the matter has never been explored, it seems appropriate to outline here the influence of Benjamin Franklin on teaching and re-

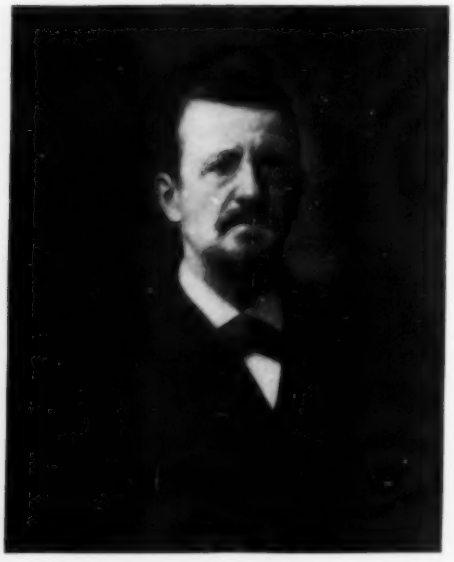
[4] Carl Van Doren, "Benjamin Franklin" (New York: The Viking Press, 1938), pp. 161–62.

ROBERT HARE

PROFESSOR OF CHEMISTRY AT THE UNIVERSITY OF PENNSYLVANIA, WHO INVENTED THE OXYHYDROGEN BLOWTORCH.

THE ENGINEERING BUILDING

FROM THE EAST. HOME OF THE TOWNE SCIENTIFIC SCHOOL, AND ERECTED IN 1904.



JOSEPH WHARTON
FOUNDER OF THE WHARTON SCHOOL.

HENRY REED
WHO AS ASSISTANT PROFESSOR OF PHILOSOPHY AND LATER AS PROFESSOR OF ENGLISH LITERATURE TAUGHT NOT ONLY ENGLISH AND PHILOSOPHY BUT ALSO POLITICAL ECONOMY. HE WAS ONE OF THE FIRST TEACHERS OF THE SOCIAL SCIENCES IN AMERICA, BUT HE WAS BEST KNOWN FOR HIS LECTURES ON LITERATURE, BEING THE FRIEND OF WORDSWORTH AND THACKERAY.

search in the social sciences in the United States as that influence showed itself in the curriculum at the University of Pennsylvania. Oddly enough that influence revealed itself for approximately 130 years in the teaching of English.

Franklin's "Proposals" of 1749 were largely concerned with the teaching of English as a tool useful in later life. The pamphlet makes it clear that the students' reading was not to be for the purpose of learning the beauties of literature but for cultivating a clear and concise style which, in either writing or speaking, would be serviceable to the good citizen. "To form their Stile," he says, "they should be put on Writing Letters to each other, making Abstracts of what they read; or writing the same Things in their own Words;" and in another place: "Indeed the general natural Tendency of Reading good History, must be, to fix in the Minds of Youth deep impressions of the Beauty and Usefulness of Virtue of all Kinds, Publick Spirit, Fortitude, &c." Furthermore, "*History* will show the wonderful Effects of Oratory, in governing, turning and leading great Bodies of Mankind," and "Modern Political Oratory being chiefly performed by the Pen and Press, its Advantages over the Antient in some respects are to be shown." Of especial significance, as will shortly appear, is the statement: "*Grotius, Puffendorff*, and some other Writers of the same Kind, may be used on these Occasions to decide their Disputes."

In fact Franklin considers that nearly the entire curriculum, through the teaching of English by means of reading, can be looked on as a part of the instruction in English, for he asks, "But if History be made a constant part of their Reading . . . may not almost all Kinds of useful Knowledge be that Way introduc'd to advantage, and with Pleasure to the Student?" Then follows a long list of useful subjects, beginning with geography and ending with "The His-

tory of *Commerce*, of the Invention of Arts, Rise of Manufactures, Progress of Trade, Change of Seats, with the Reasons, Causes, &c."

It might be argued, very reasonably, that Franklin himself did not associate "almost all kinds of useful knowledge" with the teaching of English; that he had merely passed with a hasty transition from the reading that would improve the style of English composition to the reading of history, political economy, international law and even geography. gentlemen taught is of interest to us here.

The courses given by the assistant professor of moral philosophy are as follows: to the Freshmen, "Cicero's Orations. English Grammar reviewed. Themes. Roman and Grecian Antiquities. English Composition. Declamation;" to the Sophomores, "History and Geography, ancient and modern. Rhetoric. Criticism. Elocution. English Composition. Declamation;" to the Juniors, "Logic. General Grammar.

LOGAN HALL, OCCUPIED BY THE WHARTON SCHOOL, FOUNDED 1881

But let us turn to the university catalogues to see what they reveal concerning Franklin's views as actually put into effect. In the catalogue for the academic year 1828–29, the oldest in the University Library, we find the complete curriculum, arranged according to the professors who taught the courses. There is a professor of mathematics, of languages, of natural philosophy, a professor of moral philosophy (the provost), and an assistant professor of moral philosophy. What the latter two Moral Philosophy. English Composition. Forensic discussion." In the Senior year the provost took over and taught: "Evidences of Natural and Revealed Religion. Metaphysics. Natural and Political Law. Elocution. Composition. Forensic discussions."[5]

By itself this strange medley does not

[5] The catalogue assigns the Junior course to the professor of moral philosophy and the Senior course to the provost, who were the same person. Undoubtedly the assistant professor was in charge during the Junior year, as is stated in succeeding catalogues.

HOUSTON HALL, THE FIRST "STUDENT UNION" BUILDING IN AMERICA

THE FORECOURT OF THE UNIVERSITY MUSEUM COMPLETED IN 1899
FIRST UNIT OF THE EXTENSIVE PLANT HOUSING THE COLLECTIONS IN ARCHEOLOGY AND ETHNOLOGY.

indicate that English courses were the vehicle for instruction in subjects ranging from geography to history and political science; rather, perhaps, that a small student body and a small faculty obliged the philosophy professors to teach everything that did not fall to the professors of languages, mathematics, or natural philosophy.

But if we turn to the catalogue for 1832–33, we find that a change has taken place. The courses, if they can be called

A CORNER OF THE DORMITORIES OF THE UNIVERSITY OF PENNSYLVANIA

that, are essentially the same. However, instead of being listed by professors, they are labeled *Mathematics*, *Classics*, *English*, etc., and the interesting point to observe is that the courses assigned in the earlier catalogue to the professor and assistant professor of moral philosophy are now classified as *English;* for instance, the provost's course for Seniors appears as: "English. Evidences of Natural and Revealed Religion. Intellectual Philosophy. Law of Nations and Political Law, (Kent's Commentaries.) English composition. Forensic discussions." It is interesting to observe also that the entrance requirements in English consisted of "The elements of English grammar and of modern geography." And it is likewise worth noting that the assistant professor of moral philosophy, now the famous Henry Reed, is stated to have charge of the Department of English Literature, but the curriculum gives no hint of instruction in English literature save that "Readings in Prose and Poetry" has been added to the "English" course given to Freshmen. Certainly it would seem that the university authorities in the 1830's were aware of Franklin's linking, through reading, of the teaching of English and of such subjects as geography and international law, but whether it was the result of tradition or a return to Franklin's "Proposals" it is impossible to say here.

The question may next arise, how long did this association of the teaching of history, political science and similar subjects with English continue. Before an-

A PORTION OF THE BOTANICAL GARDENS OF THE UNIVERSITY
THE BUILDING TO THE REAR IS THE ANATOMY WING OF THE MEDICAL LABORATORIES.

swering it, we will jump to the catalogue of 1873–74, in which, as for many years, English grammar and geography constituted the entrance requirements in English; and although the curriculum, after the passage of some thirty years, has evolved slightly, it is still clearly recognizable as the same. These are the "English" courses:

Freshman Class

English.—*Freeman's Outlines of History* and Lectures, with *Labberton's* Historical Atlas. Compositions and Declamations.

Sophomore Class

English.—Elements of Rhetoric. *Bains Rhetoric*, with Lectures and Practical Exercises. Earle's *Philology of the English Tongue*, with Lectures. Composition and Declamations.

Junior Class

English (Required).—Compositions and Declamations. Logic. (*Atwater.*)

English (*Elective* with *Pure Mathematics*).—Roman History (*Student's Gibbon*). Historical Lectures.

Senior Class

English (Required).—*Guizot's* History of Civilization. *Taine's* English Literature. International Law (Lectures). Social Science (*Carey* and Lectures). Compositions and Original Declamations.

English (*Elective* with *Pure Mathematics*).—Lectures on Modern History. Lectures on the Relations of English History to English Literature.

The catalogue does not directly indicate who conducted these courses, but we can assume that the work was divided between Provost Charles J. Stillé, professor of history and English literature; John G. R. McElroy, adjunct professor of Greek and history (who had once held the title of assistant professor of rhetoric and history); and Samuel M. Cleveland, professor of rhetoric and oratory.

The catalogue for 1873–74 was selected here because the Senior required course in English for that year included "Social Science (*Carey*),"[6] and because in the following year social science was dignified with the appointment of a professor of social science. This was the Reverend Robert Ellis Thompson, who since 1868 had served either as instructor or assistant professor of mathematics. But even though there was a professor of social science in 1874–75, the courses in English remained the same as in the preceding year, except that Carey's book was omitted from the required Senior course.[7]

But by the year 1880–81 a classification of courses more in accordance with our modern conception of a curriculum appears in the catalogue. Here English is clearly indicated as the study of composition, literature and philology; and history and social science are separate, each under its own label. The latter, which is given only to Seniors, appears as follows: "Social Science (Required). —International Law (Lectures). Thompson's *Social Science and National Economy.*" In almost every respect the subjects and the text-books in this curriculum are the same as before; they have merely been given new labels, and it is obvious that the new course in social science is the old required Senior English course under a new name.

The year 1881 is important for the University of Pennsylvania, and especially for the social sciences as taught there. In March of that year, Joseph Wharton, a prominent Philadelphia business man, submitted to the trustees an elaborate plan for the establishment of a "School of Finance and Economy" which he proposed to endow. In purpose, the school bore an astonishing similarity to the academy projected in Franklin's "Proposals" of 1749. The

[6] H. C. Carey, "Principles of Social Science," 3 vols., 1858–59.

[7] It is possible that Professor Thompson, while still assistant professor of mathematics, had given all or a part of the Senior course, instead of one of the other three men. In any case, however, it is obvious that the inclusion of "social science," whether Thompson or another professor introduced it, was in keeping with the practice that originates ultimately in Franklin's "Proposals."

HAMILTON WALK GATEWAY SHOWING THE ZOOLOGY BUILDING

students, well trained in English and certain other cultural subjects, would learn, through the study of history, political economy, law and mercantile practices, to become useful members of the community, both as honest and competent business men and as public servants. Of course the offer was accepted, and as a result the first university school devoted to the social sciences, in both their

THE HOME OF THE WISTAR INSTITUTE OF ANATOMY AND BIOLOGY
AND ITS FAMOUS RAT COLONIES. IT WAS FOUNDED IN 1892.

theoretical and practical aspects, was founded.

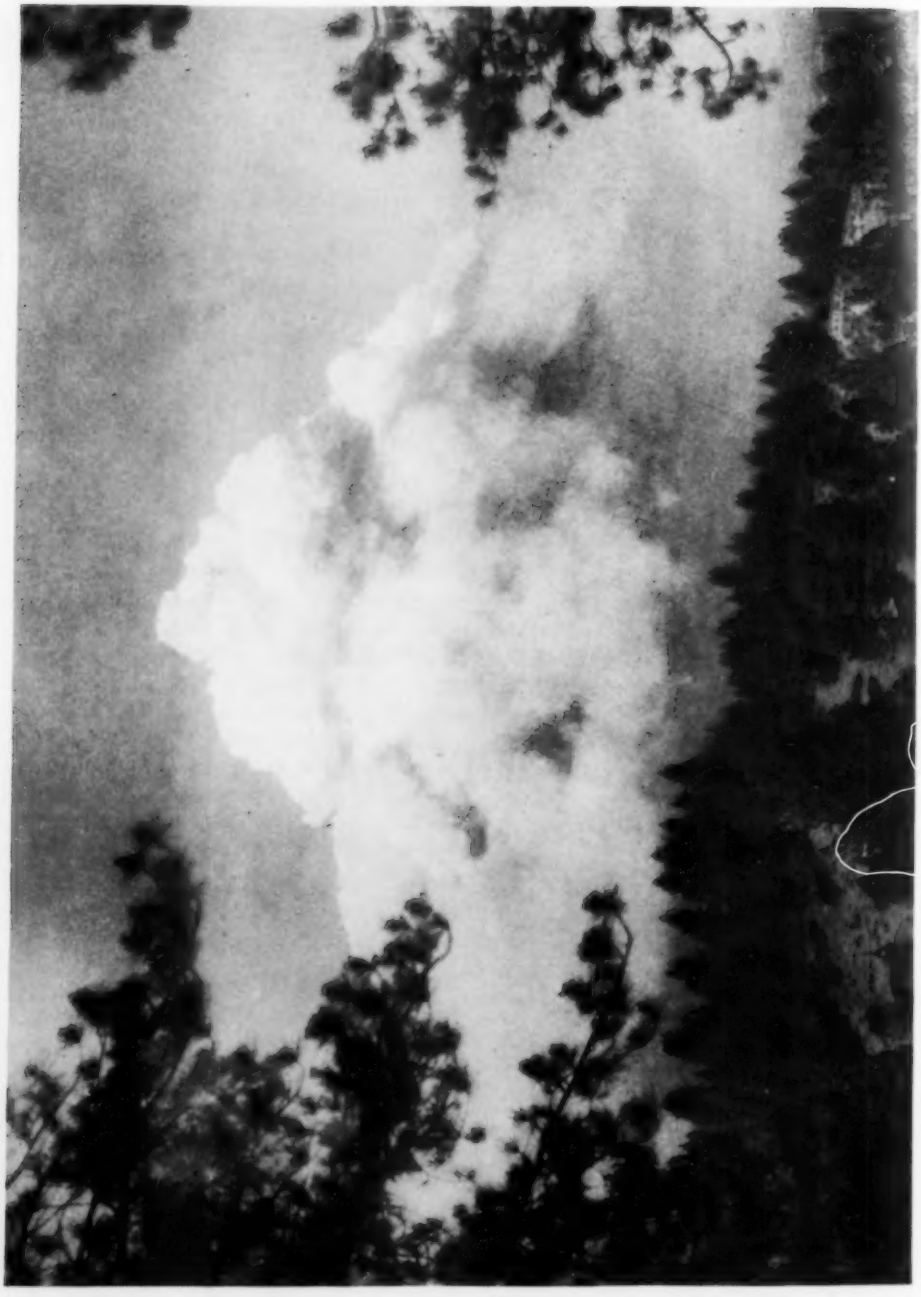
No radical change, however, in the instruction already given in the university followed. Professor Thompson continued to be professor of social science, giving the same course to Seniors in the College of Liberal Arts. But in the Wharton School announcement for 1881–82, this course broadens out into a series of courses, given only in the Junior and Senior years, on "History and Functions of Money"; "Municipal, State, and National Taxation"; "Industry, Commerce, and Transportation"; "Wage Questions. The Relations of Capital and Labor"; and "Lectures on Living Issues," such as Socialism, Communism, and free trade and protection—all of them matters, we may be sure, that Professor Thompson had treated in the original course in social science.

Professor Thompson continued to be the principal teacher in the Wharton School (his only colleague was an instructor in accounting) for but two years. For reasons that we can not explore here, he retired from the faculty of the school and accepted the appointment to the now vacant chair of history and English literature once occupied by Provost Stillé, and his work was taken over by two new appointees, Edmund J. James, professor of finance and administration, and Albert S. Bolles, professor of mercantile law and practice.[8]

Naturally, changes appear in the Wharton School announcement for the following year, 1883–84. The term *social science* is dropped and new, more precise names are given to the courses: "Political Economy," "Political Science," "History of Trade, Manufactures and Commerce," etc. However, a number of the text-books remain the same, including one by Thompson, and it is evident that the new professors built on the older foundations. It is also evident that these foundations, on which has since been erected an important school devoted to the social sciences, reach as deep as to Franklin's "Proposals."

It has often been pointed out that in his later life Franklin showed some bitterness because of the manner in which the early trustees of what is now the University of Pennsylvania ignored his proposals for the teaching of practical subjects by means of English, and made the classics a too prominent part of the curriculum. As far as actual hours of instruction are concerned, his hostility, perhaps, was justified, but it is clear, nevertheless, that his ideas possessed remarkable vitality. That they continued to be put into practice long after his death and even until to-day is revealed by what seem to us the strange combinations appearing in the university catalogues of the last century.

[8] It is significant that a third appointment to the Wharton School faculty in 1883 was that of John Bach McMaster, the historian, to a new chair of American history. The first volume of his "History of the People of the United States," appeared in that year. Something of the importance of Edmund J. James with respect to the social sciences in America is indicated by the following: "James, Edmund Janes, 1855–1925, American economist and educator (Ph.D., Univ. of Halle), was professor of public finance and administration at the Wharton School of Finance and Economy [now Finance and Commerce] Univ. of Pennsylvania, 1883–96, and a leader of the so-called Pennsylvania school of economists. He was a founder of the American Economic Association (1885) and of the American Academy of Political and Social Science (1890), becoming the first president of the latter organization."—*Columbia Encyclopedia*, New York: 1935. The Economic Association is now affiliated with the American Association for the Advancement of Science. Professor Bolles wrote extensively on the history of American industry and finance.



A HEAVY SMOKE CLOUD FROM A LARGE FIRE

PROGRESS IN FOREST FIRE CONTROL

By GEORGE M. GOWEN

CHIEF OF FIRE CONTROL, REGION 5, U. S. FOREST SERVICE

THE drier the fuel and the better the draft the easier a fire may start, the hotter it burns and the more difficult it is to extinguish. In these respects forest fires are comparable to fires built in a fireplace or stove.

Dryness of forest fuels depends on their moisture content. In turn moisture content depends on the amount and distribution of precipitation, the current relative humidity, evaporation rate and insolation.[1]

Local analyses of weather records, particularly in the West, where a large portion of the national forest area lies, indicate that precipitation in the forested areas has not only varied from year to year but also has exhibited distinct wet and dry periods or cycles. It appears that we are now in the driest of these dry cycles and that the general trend of precipitation is still downward. In addition to a general decrease in the annual precipitation, there seems to be a growing tendency for the distribution of the rain which does fall to be less general in extent as compared with past years. The records also indicate a general rise in temperature, slight, perhaps, but enough to influence fire danger to some extent.

Since precipitation is the basic source of the water content of forest fuels, it seems reasonable to expect that deficiencies in precipitation will result in drier forest fuels and consequently greater seasonal fire danger. The probability of forest fires covering larger areas and causing greater losses, of course, increases as the fire danger or severity of fire weather increases.

Despite fire weather conditions increasingly adverse to protection of the forests from fires, the area burned in the 200 million acres within national forests of the United States has been reduced consistently decade by decade. Using as an index the area burned over per million acres protected, the figures given in Table 1 illustrate this progressive reduction by 5-year periods.

TABLE 1

5-year period	Average annual acres burned
1910–1914	8,400
1915–1919	6,300
1920–1924	3,100
1925–1929	3,600
1930–1934	2,400
1935–1939	1,480
1940 only	1,525

A single year of the 1940–1944 period is not sufficient to identify the continued success or a failure of fire-control efforts. However, in 1940 the more unfavorable fire weather, abnormal number of fires and concentration of large numbers of lightning fires in certain areas combined to produce a situation in which large losses might ordinarily have been expected.

During one 13-day period in 1940, July 11 to 23, the Northern Rocky Mountain Region was showered with over 1,700 lightning fires. This was twice the number ever previously experienced in any area and three times the total previously recorded in the 28,000,000 acres of the Northern Rocky Mountain Region, in so short a period. The gigantic task of assembling men to handle such a large

[1] A discussion of the interrelationship of the several phases of forest fire control appeared in THE SCIENTIFIC MONTHLY for July, 1939, pp. 21–30, "Forest Pyrology," by H. T. Gisborne, senior silviculturist of the Forest Service.

A HEAVY SMOKE CLOUD FROM A LARGE FIRE

DELIVERY OF SUPPLIES[1]

FIRE FIGHTING SUPPLIES ON SIMPLE BURLAP PARACHUTE. THE STREAMER ALLOWS GROUND FORCES TO LOCATE THE LOAD READILY WHEN IT DROPS IN HEAVY COVER.

suppression job, transporting them to the fires and supplying them with tools, equipment and subsistence, although seemingly impossible, was done. The 1,700 fires were controlled with a loss of but slightly over 7,000 acres.

Except for the steady advance that has occurred in the various fields of fire control, the 1940 story might have been quite different. Losses might have increased substantially. Instead, the record shows approximately no increase over the previous 5-year average. Increased effectiveness in preventing fires from starting, in putting them out while still small, and in promptly controlling those which escape the initial attacking forces, have resulted from continuing efforts, through the years, to improve techniques and devise new methods of meeting the fire problem.

The old saying "An ounce of prevention is worth a pound of cure" applies doubly in the case of man-caused forest fires. Almost 50 per cent. of the 17,000 fires occurring annually within the national forests are of this class. Closer and closer analyses of the causes of individual fires and the underlying reasons behind them have, in many cases, permitted remedial measures to be devised and applied. Such measures have not resulted in a reduction of the total number of man-caused fires, but they have been effective in materially reducing the ratio between numbers of fires and the constantly increasing number of forest users and visitors.

The total number of fires is much too large and presents far too great a threat of loss. To reduce this total to a minimum and hold it down, is the goal of fire prevention. Education in what constitutes carelessness with fire and how to be careful has been an important part of fire prevention work. It is a continuing job, because of new users and the new generations who will become future forest users.

Positive measures—such as clearing railroad, highway and power line rights of way, use of spark arresters on automotive and steam equipment, providing prepared camps for the camping public, and regulation of the time and place for burning debris—have had their effect in holding the number of fire starts far below that which would have occurred if sustained efforts in this direction had not been made. Incendiary fires, those wil-

[1] Photographs by courtesy of U. S. Forest Service.

fully started with the intention of destroying the forests, are probably most difficult to prevent. A strenuous attack on the problem in one area, however, secured a reduction from well over 200 such fires a year to less than 20.

The organization needed to cope with the fire problem varies with the fire danger. Current measurement at established fire-danger stations of the factors influencing fire danger, and integration of these factors, together with fire-weather forecasts supplied by the U. S. Weather Bureau, provide a day-to-day basis for setting up an adequate fire organization. It has been evident that this system which permits the administrator to know in advance what fire weather may be expected and to take prearranged steps to meet the predicted danger has helped to reduce the fire losses.

Success in fighting fire depends on all those engaged in the job doing the right thing in the correct manner at the right time. In order to attain this each man of the fire control organization must be trained in the methods and techniques of controlling forest fires under a variety of combinations of cover types, topography and weather conditions; in proper use of tools and operation of equipment; in organizing and working crews of men efficiently. Added impetus to training within the past decade has prepared fire control men to handle their work with fewer errors and omissions.

As in practically all other fields of human endeavor there has been the same constant urge to increase the tempo and demand more speed in all the stages of action on a forest fire. Minutes saved in the early stages of fire can well mean hours of toil saved. The quicker one of the larger fires is encircled with a control line, the smaller the acreage burned, the loss and cost. Mechanization, which is growing in fire control work, in many

PARACHUTE JUMPER ON HIS WAY TO A FIRE
NOTE SMOKE OF FIRE IN LOWER RIGHT FOREGROUND.

cases permits the demanded increase in speed of either the attack or the control of the fire.

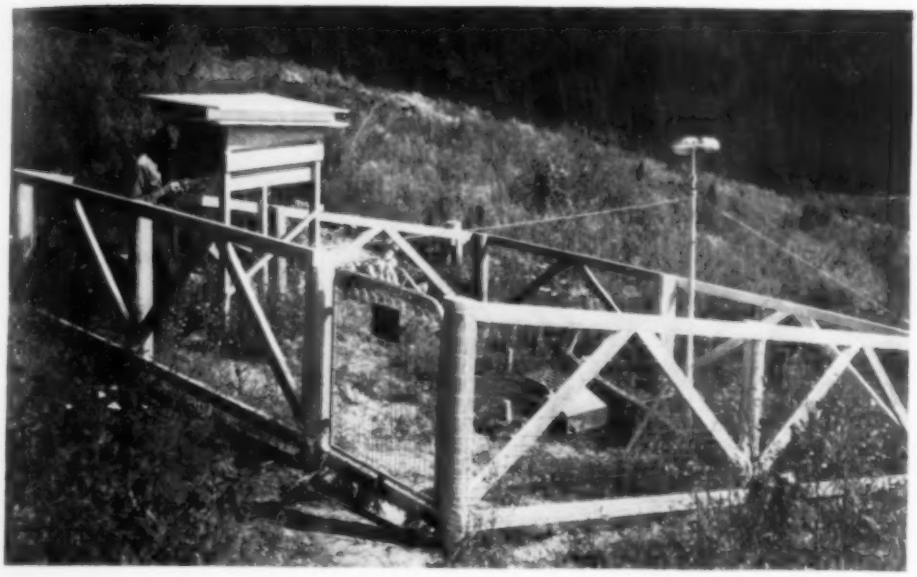
A large mileage of forest-protection truck trails (roads) built for fire-protection purposes in the past years by the Forest Service, the CCC and under emergency programs permits many fire guards to be motorized and to reach fires in minutes instead of hours as formerly when they had to travel by foot or horse. Portable radio equipment enables the guard to call back promptly from the fire in case help is needed or to let headquarters know that he is able to control the fire alone. Forces of men needed for suppression work are now transported by truck or bus over these roads to points as near the fire as possible. Previously it was often necessary to hike for hours and sometimes days to reach the scene of a fire.

Tractors, with a dirt-moving blade attached in front or dragging large strongly built plows, have come into widespread use in building the fire line on the larger fires, even in the more mountainous areas. Such equipment permits a fire line to be built at a much faster rate than could be accomplished by man-power. It also reduces the man-power requirements and is not subject to progressively decreasing production resulting from fatigue as men alone would be. As an example, in one national forest region in the past two summers, tractors constructed some 400 out of a total of approximately 1,500 miles of fire line on all fires which occurred in this area. Large logs are removed easily from the fire line or adjacent to it by the tractor. Formerly logs had to be cut in sections and rolled out by hand, a slow and laborious process, often impossible in the face of a fast-running fire.

Perhaps the most spectacular mechanization development in fire control is the use of the airplane. It has been adapted

PARACHUTE JUMPERS AND TWO TYPES OF PARACHUTE

PROTECTIVE SUIT AND SPECIAL PARACHUTE SHOWN ON THE BACK OF THE MAN TO THE LEFT. THE PARACHUTE ON THE FRONT IS OF STANDARD DESIGN, WORN AS AN ADDITIONAL SAFETY FACTOR.



FIRE DANGER RATING STATION, KANIKSU NATIONAL FOREST

to several distinct fire control purposes. For about two decades the airplane has been used after lightning storms or during hazy or smoky periods to search for small fires which may be burning in areas not visible to established lookout stations.

For several years the airplane has been used to drop supplies to suppression forces who are fighting inaccessible fires or isolated sectors of large fires. By means of simple inexpensive burlap parachutes all types of needed supplies, tools and equipment are dropped to the fire fighting forces. Short-wave radios to permit communication between the forces on the fire are dropped successfully and without damage. Even crates of eggs and prepared hot meals are delivered to the ground forces. Water is dropped in 5-gallon tins for thirsty fire fighters on ridge tops far removed from springs or streams.

One of the most important advantages of delivering supplies by airplane is that it enables the forces to bivouac on or near the fire line where the work is located rather than to waste from 2 to 4 hours of a 12-hour shift in mere walking over rough terrain and climbing to high elevations from the base fire camp to the distant fire line. Of equal importance is the fact that needed numbers of men can be placed on a fire immediately when delivery of essential food and equipment is assured.

During the fire seasons of 1939 and 1940 a total of over 500,000 pounds of food, tools and equipment was delivered by parachute in the western United States hours and sometimes days before mules could have delivered these supplies.

When the occasional large fire occurs on a national forest, there is seldom sufficient overhead personnel locally available to direct the efforts of the forces employed for the job. While the laborers needed to wield the axe and shovel can be recruited from nearby labor centers in a relatively short time, the overhead must be obtained from adjacent or even distant national forests. It is

TRACTOR TRAILBUILDER BUILDING FIRE LINE, LOLO NATIONAL FOREST

fruitless to place laborers on a fire unless trained and experienced men to direct their efforts accompany them.

Speed in getting overhead to the fire must equal that of recruiting the laborers. The answer to this is airplane travel. As an example, when last season 500 laborers additional were required to control a fire, it was possible for the laborers to assemble and to reach the fire within a few hours to be available for the next work-shift. The 50 overhead required to direct these men were not available locally but were transported by plane from national forests as far as 550 miles distant in less than 4 hours. If automobile, bus or train travel had been relied upon, this overhead would not have arrived for at least 12 to 24 hours and would have required a rest period from the fatigue of travel before they would have been capable of carrying out their assignments on the fire.

Parachuting men to fires in inaccessible areas is a recent development which has attracted much attention. Through extensive experimentation the technique of parachuting, landing in the desired location and the development of protective jumping suits, guidable parachutes and featherweight radios for use by the jumpers have been developed. A fire which would require many long hours of hiking over mountain trails or through well-nigh impenetrable cover can be reached in less than an hour by a fire fighter floating down from a plane. This saving in time, this increase in speed of attack means that one or two parachute jumpers can often reach and control a fire in a dangerous location while it is still small. Horse or foot travel to similarly located fires would inevitably result in a much larger fire, burning for days instead of hours, with attendant high damage and great expense to control.

In 1940, on a more or less experimental basis, two-man fire fighting crews parachuted to nine fires which were in especially inaccessible and dangerous areas, where under existing conditions fires would spread rapidly and become large

before usual suppression forces could reach them. Parachute jumpers were able to reach some of these fires in an hour or less. Ordinary modes of travel would have taken from 24 to 40 hours. The remaining fires attacked from the air were reached in from one to three hours, resulting in similar time savings.

As an example, on the evening of August 20, a lightning storm unaccompanied by rain hit the Moose Creek Ranger District in the Northern Rocky Mountain Region. Sixteen lightning fires were started in the area in which there were but 11 men available to handle the fires. Four parachute jumpers were dropped to two of these fires with the result that they controlled the fires when still less than one quarter of an acre each. Six of the remaining 14 fires were quite comparable in all respects to the two which the parachutists attacked, except that they were more readily accessible to roads. These fires burned from 100 to 1,000 acres each and cost from $2,000 to $13,000 to control as compared with the two fires controlled at one quarter of an acre each by the smoke jumpers at a total cost of less than $500. It is conservatively estimated that if ground forces had been depended upon, the cost of suppressing the nine fires attacked from the air would have amounted to no less than $32,000 as contrasted with $9,047, the total cost of maintaining the parachute suppression forces for the full season. Actual suppression of all these fires cost only $2,250, excluding non-firefighting time of the men when engaged in other work and awaiting fire calls. This indicates a net saving of almost $30,000 in expenditures with a reduction in area burned of several thousand acres.

Speed in controlling forest fires is also being advanced by the development and use of other specialized equipment such as portable water pumps, tank trucks, power fire-line construction machines, portable radios, power felling and bucking saws, power flame throwers for rapid back-firing of lines that must be burned out to stop the advance of the fire, small tractors for transporting small crews and supplies over trails where there are no roads, and other similar equipment. Equally important but less arresting is the increasing study and improvement of methods of working men on the fire line to increase production and to reduce waste effort and time commonly experienced in emergency work such as fire fighting.

Although considerable progress has been made, the losses are still too great. A loss of 318,000 acres per year, the 1940 burned area, would be equivalent to a loss in 10 years of over 3,000,000 acres, too great a depletion of our natural resources to be countenanced. When forests burn, productivity for the period until the resources lost are again replenished and available for use must be recognized as well as the monetary value of the resources destroyed.[2]

[2] The resources of the national forests and their importance to the welfare of the nation appeared in THE SCIENTIFIC MONTHLY for August, 1939, "Forest Conservation and National Security," by Richard F. Hammett, U. S. Forest Service.

ANT MOUNDS IN SUMMER WOODS

By Dr. E. A. ANDREWS

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ACCORDING to the old fable the grasshopper came to the ant to beg food which the industrious creature had stored up for the future while the grasshopper had spent the summer singing. And in the scriptures we read that the ant "having no guide, overseer or ruler yet stores up its meat for the winter." Yet this is not true of all sorts of ants and if we take as example the kind known as the mound-building ant of the Alleghanies, or to the entomologist as *Formica exsectoides* F., we will soon find that its chief concern is with its daily bread, with no reference to storage for the winter, and indeed we will come to realize that it is only its fine house and family that insures this kind of ant against the terrors of the winter.

A mound such as seen in Fig. 1 often swarms with ants much of the summer time; ants all running at such speed that the camera fails to show them, each working quite separately, here and there on the roof of their great community house, which is so vast as compared with the ant itself that the Reverend H. McCook calculated the great pyramid of Cheops was small work for man, in comparison. We see each ant struggling up the slope with maybe a stick ten times its length held up in its jaws, as if a man carried a telephone pole, or maybe a stone great in bulk and weight, but if not to be lifted then dragged behind as the ant runs straight backward and yet rapidly. Whether near the top, over the top or on this side, the ant suddenly releases its burden and runs down for a new load. Objects are picked up from fifty feet roundabout and brought to add to the mound which thus becomes, in close-up view, Fig. 2, covered over with small objects of many kinds looking like a sort of museum of what can be found in the neighborhood. Though thus gathered bit by bit by ants seeming to have no knowledge of the works of the others, yet the mass takes on the form we see in an hour-glass where the sand falls from a central

FIG. 1. AN ANT MOUND MADE PARTLY OF CHARCOAL

SINCE THE CHARCOAL BURNERS CUT THE FOREST NEW TREES HAVE SPRUNG UP AND THE ANTS HAVE MADE THEIR GREAT MOUND DARK WITH BITS OF CHARCOAL. THE SIX-INCH RULE GIVES THE SCALE.

point above. But for all this work the ant must eat: and ancient wisdom informs us that the ants "are a people not strong, yet they prepare their meat in the summer." Follow the ants far enough and you may see the way meat is got—some or many ants mobbing a worm or insect, eventually killing it and dragging it back to the mound, where it is lost to sight in some of the many openings round the bottom of the mound. But it is the liquid food the ants bring home that is their chief staple, and this can be traced to some tree inhabited by plant-lice or other insects that suck the sap and give out what is known as "honey-dew," of no use to them but welcomed by the ant as a substitute for milk. Each ant becomes gorged with honey-dew, and coming down the tree weighs a third more than when he went up.

All food, however, is not long held as private property, but it is shared with those who have less, till the entire community profits. Among the beneficiaries are the numerous young ants coming from eggs laid by the few mothers, known as "queens" who alone supply the community with new members to be fed and cared for by the working ants, which may be also builders and providers.

For the eggs and young certain temperatures are necessary, and here the ant seeks the aid of the sun. If we put thermometers into a mound, as in Fig. 3, we find out that the top is the warmer part, the north region the cooler and other parts varying as the day advances and the sun shines on different parts successively: while at night all grow cooler, but not as cool as the surrounding earth, since, as in our houses, there is stored up heat under the tight roof, lasting on into the next day.

That the ants do not only utilize the warmth of the sun but prefer certain temperatures rather than others, is

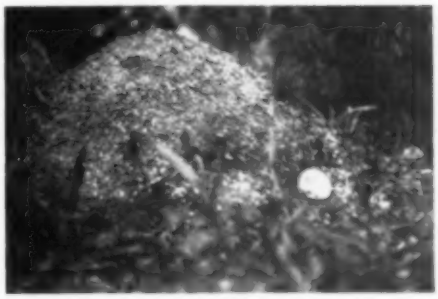

FIG. 2. A SMALLER MOUND

MADE BY ANTS TAKEN TO A NEW REGION. THE SURFACE IS COVERED WITH SMALL STICKS AND WITH WHITE SPECKS THAT WERE BITS OF FOSSIL SHELLS PLACED THERE BY THE ANTS. THE ANTS DID NOT PUT THE WATCH THERE.

known from keeping them in glass enclosures with thermometers and noting the places to which they carry their eggs and young; by finding the young in that part of the mound showing certain temperatures; and by sometimes seeing the ants coming out over the roof of the mound to carry their young to a more favorable part of the interior of the mound.

FIG. 3. TAKING TEMPERATURE

OF ANT MOUND. THERMOMETERS STUCK INTO A MOUND AND LAID ON ITS SURFACE TO TELL HOW THE HEAT OF THE SUN WARMS THE INSIDE, SO THAT IT IS FIT FOR REARING YOUNG.

FIG. 4. PARTIALLY MOSS COVERED
ALONG THE ROAD BY THE WOODS' EDGE THE MOUND IS THATCHED WITH FRAGMENTS OF PLANTS BUT ON THE SHADED FACE MOSS COVERS THE LOWER PART. THE RULE IS SIX INCHES LONG AND MARKS THE UPPER LIMIT TO WHICH THE MOSS HAS GROWN.

With food, with right sun warmth and with moisture most fitting, all goes well; eggs hatch as grubs, grubs rest in cocoons that look somewhat like grains of wheat, to emerge later as full-sized ants to increase the population from time to time in numbers to be inferred from tally of the cast-off swaddling clothes brought out by the old ants and deposited as frail additions to the roof, soon scattered by the winds.

The thousands of young ants added during the summer may more than make up for the losses by accident and old age; then the community grows and with it the mound is builded greater through thirty or more years. But this property handed down from generation to generation must be kept in repair; the rains tend to destroy it, and if the ants abandon it the mound soon becomes as in Fig. 5, covered with little pinnacles of firmer earth, the posts, columns and buttresses of the house, not as readily washed away as are the walls of the ants' chambers and passageways; but eventually all the mound will vanish and nothing but softer earth represent its site. Too much shade is bad for the community—they work best in the sun. The north face of the mound may be neglected and moss growing up over it, as in Fig. 4, may take entire possession when the ants migrate to some new site. It is true the ants do actually bite and irrigate with strong formic acid young trees and plants growing near their mounds, but yet trees will grow and may finally overshadow the mounds, so they are abandoned by the ants.

On the other hand, as old mounds disappear new ones may spring up, as in Fig. 6, where some kindly wind felling the trees made an opening in the dense woods and there the ants found a place

FIG. 5. IN MAY A MOUND LONG ABANDONED BY ITS INHABITANTS
WORN DOWN BY RAIN TILL THE SURFACE SHOWS LITTLE PINNACLES OF RESISTING EARTH AND SOME LITTLE PEBBLES NOT WASHED AWAY. THE SCALE AT TOP OF THE MOUND IS SIX INCHES LONG.

FIG. 6. ANT MOUNDS CROWD CLOSE TOGETHER TO ENJOY THE SUN
WHERE THE WIND HAS THROWN SOME TREES IN THE PINE WOODS.

in the sun, not only for one, but for several mounds close together. Thus a preferred region may count hundreds of mounds, forming a city or state; mounds dying away here and new ones arising there, shifting the center of population, but ants living on in the same general region indefinitely.

PETROLEUM IN THE UNITED STATES

To an unprecedented degree, petroleum has become an essential in the waging of war.

The position of the industry, as to production, distribution and resources, and its capacity to expand and enlarge its services are of utmost consequence at this time. In 1940, production of crude oil in the United States was 1,351,847,000 barrels. This production was 63 per cent. of the estimated world's total, and 23 times the total production of the Axis nations. It came from 392,268 producing wells, of which 19,773 were completed during the year. Known oil reserves in the United States approximate 19,000,000,000 barrels, and the national inventory of petroleum products as of December 31, 1940, was 563,594,000 barrels.

Total transportation facilities included 316,000 miles of crude oil, gasoline and gas pipe lines; 146,000 tank cars; 140,000 trucks (all kinds); and over 400 marine tankers of 2,770,000 gross tonnage. Refineries in the United States having combined capacity of 4,181,000 barrels of crude oil daily were operating at the end of 1940, with additional capacity of 680,000 barrels daily shut down or building. In addition, cracking plant capacities capable of turning out 1,021,000 barrels per day of cracked gasoline were operating, with 130,000 barrels capacity shut down or building.

From the foregoing it is clear that as far as any probable national emergency is concerned the American oil industry is prepared. About an ample supply of crude oil to meet such emergency, there need be no concern. Transportation of crude from oil fields to refineries offers no problem. Manufacturing and distribution facilities are adequate to all needs, military and civil.—*Standard Oil Bulletin, April, 1941.*

THE CHARACTER OF WEATHER

By Dr. ADELBERT K. BOTTS

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WEATHER is capricious. It is fickle, undependable, inconstant. For the great majority of people in the United States the most apparent characteristic of weather is its changeableness. From January first until December thirty-first the weather provides, for most of us, a continuous, fluctuating succession of "spells," involving innumerable combinations of heat, cold, sunshine, cloudiness, rain, drought, wind and calm, usually with no apparent rhyme nor reason to the process.

Early man turned to the gods for his explanation of the weather. According to the temper and affection of the gods for their children, destruction and hunger or love and plenty were dispensed through the agencies of ever-changing weather. Having provided satisfactory explanations for the causes of weather changes, man's next task was to learn how to forecast the changes. Sages sought signs. A vast body of weather lore evolved. In the development of weather lore man acquired the rhyme as well as the reason for weather conditions.

When the wind is in the east, 'tis good for neither man nor beast.

When the wind is in the south it blows the bait to the fishes mouth.

These, with a multitude of local additions and variations, comprised the "weather prophet's" stock in trade. And we must not be haughty in our attitude toward prophets and their lingo, for, although often scorned by science, many weather proverbs have firm foundations in fact.

After reaching that happy state where he knew both the cause and the signs of the weather, man might have been satisfied. But he wasn't. Skepties questioned not only the function of the gods, but the validity of the weather signs as well. Benjamin Franklin is recognized among the skepties. His numerous experiments and observations led him to revolutionary conclusions. Besides identifying electricity as a phenomenon of weather, he is credited with observations which helped to establish the fact that storms tend to travel from the west toward the east.

From that idea gradually developed the concept of weather as a series of eastward-moving storms. With the aid of barometers scientists learned to identify storms with changes in air pressure. Eventually they devised a classification of storms based on barometric pressure conditions. The weather nomenclature of that period included such terms as "isobar," lines on maps connecting places of the same pressure; "cyclones," areas of low barometric pressure, more commonly referred to as "Lows"; and "anticyclones" or "Highs," areas of high pressure.

The United States Weather Bureau, originating in 1870, established its splendid system of observing, reporting and forecasting weather while the influence of the air pressure meteorologists was at its height. The Weather Bureau publishes daily weather maps on which storms are identified as "Highs" or "Lows," depending on whether high or low atmospheric pressure dominates the center of the storm areas. Careful analysis of pressure areas over a long period of years has taught forecasters to

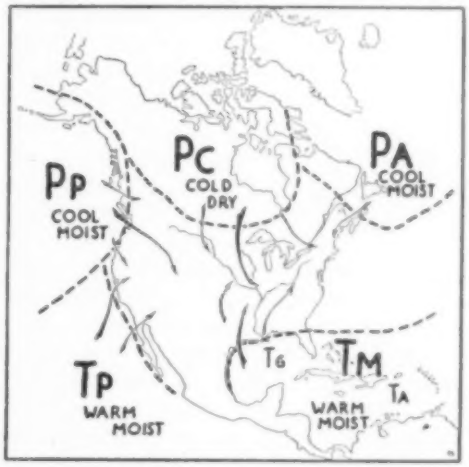
associate rather definite weather phenomena with "Highs" and "Lows" and with their various parts. Knowing the general characteristics, the paths and the usual rate of movement of storms, forecasters have been able to achieve a very high degree of accuracy in prognostication.

But again skeptics have arisen. Their activities have developed an "air-mass analysis" system of weather study. "Air-mass analysis" students contend that their system of weather study is more accurate and dependable than the "barometric system" because it deals with the whole atmosphere of a region rather than with a limited number of phenomena. Whereas the older system studied "High" and "Low" pressure areas, the newer system analyzes "air-masses."

An "air-mass" consists of a highly homogeneous body of atmosphere several hundred miles in horizontal diameter, three to five miles thick. Each "air-mass" is a separate and distinct individual possessing characteristics distinguishing it from its neighbors. Some "air-masses" are cold and clear, some warm and rainy, some cool and rainy; and a few are warm and dry. A succession of contrasting "air-masses" passing over a locality provide frequent and occasionally violent changes in weather within brief periods of time.

Air-masses affecting the United States appear to originate either in the high pressure zone lying to the south of us or in the polar high pressure zone. Masses from those two sources approach each other, generally arrange themselves in alternating succession, overlap along the zones of contact and march in an easterly direction across the country.

The character of any individual air-mass develops at the point of that individual's origin. Masses originating in the tropics acquire tropical characteristics; those from polar regions become polar in their nature. Oceanic air-masses are mild and damp. Continental air-masses display extreme temperatures and low moisture content. Each tends to maintain its original character as it passes across the continent, but its success in that regard depends mainly upon the speed at which it travels and upon the nature of the land surface over which it moves. A slowly moving mass is an inconstant mass. The land or sea over which it passes conveys to its lower layers many modifying characteristics. High mountains in the paths of air-masses cause them to drop their moisture



REGIONAL CLIMATE MAP

and often change their temperature as well.

Air-masses are named and identified according to their regions of origin. Perhaps the three most common air-masses visiting the United States are Polar Continental (commonly called Pc), Tropical Gulf (Tg), and Polar Pacific (Pp). In addition to these, others that visit our country are Tropical Pacific (Tp), Tropical Continental (Tc), Tropical Atlantic (Ta) and Polar Atlantic (Pa). If, because of slow rate of travel or because of obstructions in their paths, air-masses suffer modification they lose some of their distinctive

characteristics. Such changes in character necessitate changes in name. In such a manner a slowly moving, mild Pc (Polar Continental) air-mass becomes an Npc (Modified or Neutralized Polar Continental) air-mass. The Pc, as before, indicates the source and essential character of the mass. The N testifies to changes that have occurred in transit. All other modified air-masses are likewise identified by an N placed before the original initials.

The names indicate that dominant characteristics in air-masses are engendered by two sets of opposing factors. On one hand, polar versus tropical factors provide cold or warm air for the masses. On the other hand, factors of continental versus marine nature determine the severity or mildness of the temperatures as well as the amount of atmospheric moisture.

Continental climates are notoriously extreme in temperature conditions. If they are cold they are extremely cold; if hot, infernal. Usually, also, they are dry. As a consequence, air-masses moving out of a region with a continental type of climate possess extreme temperatures and low moisture content. Polar continental North America experiences extremely cold weather during eight or ten months of the year. At such low temperatures the atmosphere is unable to contain much water vapor. For those reasons the weather is clear, cold, crisp and dry.

As an air-mass moves out of such a region it transports to regions lying south and southeast of its point of origin a first-rate sample of McKenzie or Hudson Bay weather. Such masses are particularly frequent in the northern states during the winter. There they account for most of the clear weather and for the "unseasonably cold" weather. Occasional pure Pc (Polar continental) air-masses move directly from north central Canada to the Gulf of Mexico. On such occasions the newspapers are filled with descriptions of the "cold wave" and of "freezes" paralyzing the Gulf Coast and destroying the citrus crops of Florida. Such air-masses also furnish us with frosts on clear nights in early autumn and late spring.

Marine climates are generally mild. In winter they are warmer than continental areas of similar latitude. In summer they are cooler. Consequently, air-masses originating in areas with marine types of climates are less extreme in temperature than continental air-masses. Also marine air-masses are more humid than are those of continental origin.

But marine air-masses are not all equally humid. The contrast between those coming from polar regions and those coming from tropical regions is very marked. That is because warm air can contain more moisture than cold air. Thus, most of the rainfall of central and eastern United States east of the Rocky Mountains comes with tropical marine air-masses. Among that group the Tg (Tropical Gulf) air seems to be the most dependable and least erratic provider of precipitation. Tp (Tropical Pacific) air has little opportunity to serve more than a small section of the southwest because of the great distance to be traveled and of the high mountains in the path. Ta (Tropical Atlantic) air is, compared with Tg (Tropical Gulf) air, a relatively infrequent visitor but a most lavish spender of its liquid assets when it does come. On several occasions, warm, damp Tropical Atlantic air has moved directly from the sea into the northeastern states where it wedged itself in between stable, cold air-masses from the north. In such a situation it is literally accurate to say, "It doesn't rain but it pours." As evidence of the work of Ta (Tropical

Atlantic) air-masses are the New England flood of November, 1927, the New York flood of July, 1935, and the general flood of the Northeastern states in March, 1936, as well as the hurricane of September, 1938.

All parts of the United States have some variety in the air-masses that visit them. The far Northwest receives Pp (Polar Pacific) air most frequently, but Tp (Tropical Pacific) and even Pc (Polar Continental) air visits that area occasionally. The southwestern coast enjoys Tp (Tropical Pacific) air-masses more frequently than its northern neighbor; but it does not lack entirely the more stimulating air-masses from the north and from the continent. Southern California summer weather embraces some hot dry Tc (Tropical Continental) air-masses which originate in the arid region of Northern Mexico at that season.

Air-masses tend to move in an easterly direction, but once in a while they swing to the west or travel directly north or south before adopting the eastern component of their itineraries. Consequently, the western mountain section receives parades of Pp (Polar Pacific), Tp (Tropical Pacific), and Tc (Tropical continental) air-masses with winter Pc (Polar continental) masses for added variety. Throughout much of that section of the country Pp (Polar Pacific) and Npp (Modified Polar Pacific) air dominates, bringing heavy precipitation to the western sides of the mountains and mild but dry weather to the eastern sides.

The northern plains and prairies, eastern Montana to northern Ohio, add strong Pc (Polar continental) masses to the procession, while the southern states contribute Tg (Tropical Gulf) air. As is the case in all parts of the country the number and intensity of the dominant air-masses of these regions fluctuates with the season. The masses from the Gulf are more numerous and intense in the summer. Those of polar continental origin dominate in the winter.

To be sure, many of the weaker western air-masses lose their identity by mixing with larger and fresher masses before they reach the eastern states. Tp (Tropical Pacific) air and Tc (Tropical continental) air reach the eastern coast only on rare occasions. Pp (Polar Pacific) air is almost always modified by its journey over the mountains and across the plains.

In spite of these losses and modifications the northeastern states from Maine to Virginia are in a position to view the parade of air-masses at its most varied best. In that region it is an unusual month, indeed, which does not experience Tg (Tropical Gulf), Ntg (Modified Tropical Gulf), Pc (Polar Continental), Npc (Modified Polar Continental) and Npp (Modified Polar Pacific) air-masses. In addition to these "standard" masses a little pure Pp (Polar Pacific) and some Ntp (Modified Tropical Pacific) or Ntc (Modified Tropical Continental) air from the west may assert itself. From the east Ta (Tropical Atlantic) air, heavy with rainfall and Pa (Polar Atlantic) wielding a "northeaster" may join the procession and give added variety to the weather.

The ever-changing succession of air-masses passing over an area does provide an abundance of variety. However, the relations of one air-mass with its neighbors increases still further the complexity of weather probabilities. Between every two adjacent air-masses there is a zone of contact and mixture with a "type" of weather all its own.

Zones of contact and mixture between neighboring air-masses are called "fronts." The zone between a cold air-mass followed by a warm one is a "warm front," that between a warm mass followed by cold air is a "cold front." Air-masses differ in density primarily be-

cause of differences in temperature and moisture content. When they meet, the colder one being denser and drier than the other stays close to the ground and forces the warm, moist air along the edge of a warm air-mass to rise. In a warm front the warm air crowds into the rear of a cold air-mass. In that situation the warm air climbs up over the edge. The back side of the cold air-mass becomes a long gentle slope up which the warm air climbs as if it were climbing a hill, and the effects are almost the same. Warm fronts are usually rainy because as the warm air climbs the "cold air hill" it becomes cooled, clouds form and precipitation forms. But the warm front rains are not usually stormy. The processes involved in the climbing are relatively mild and seldom result in severe conditions.

On the other hand, cold front weather is nasty weather. As in the case of warm fronts, the cold air stays close to the ground and forces the warm air to rise, but in cold fronts the process is often a violent one. As the cold air advances into a region occupied by warm air it displaces the warm air by crowding under it. Consequently, the warm air, on frequent occasions, is forced to rise with rapidity and much turbulence. Turbulence results in local storms. The severity of storms depends upon the violence with which the displacement of air occurs and upon the amount of air involved. Cold front storms vary all the way from gusty weather to the most destructive tornadoes. Squalls, thunderstorms, hailstorms, "dusters," blizzards, tornadoes—all are commonly born in cold front zones.

Because of its frequent definiteness the approach of a cold front is one of the most easily observed weather phenomena in many parts of the United States. It usually advances from the west, accompanied by high, black, rolling clouds, and regardless of the time of day, may cause an abrupt and distinct reduction in the temperature. A five or six degree reduction of temperature within a few minutes is not unusual with the arrival of a cold front.

Weather does have rhyme and reason. It is difficult for us to appreciate the rhythmic sequence of warm and cold air-masses, especially when that sequence contributes to the making of such headlines as the following:

Relief Marshaled for South as Toll of Tornado Rises

135 Dead, 200,000 Homeless in Floods; Wheeling Deluged, Washington Hit, New England Cut Off above Hartford

Buffalo Area Gets 24 Inches of Snow
Soggy fall continues and city, out of removal funds, lets traffic halt

Cold Wave Moves East in Storm's Wake
Many towns snowbound in Dakotas

West Plagued by Dust Storm and Cold Wave

Thunderstorm Breaks Heat of 81; Cloudburst Floods Nyack as Dam Gives Way

In the midst of one of these phenomena we lose sight of the succession of related events contributing to its occurrence. It is only when observing the weather over an extended period of time or abstractly as on a map that we can truly appreciate the beauty of the system and realize that air-masses passing across the country do respond to definite laws of rhyme and reason.

THE REAL IN ART

By Dr. JAMES BYRNIE SHAW

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1. Creator and Created

In order to appreciate an artist's production one must reproduce in himself the living state of the artist when he created his expression. This means he must permit those processes in the artist's spirit and in his own which are essential in the creative act to have full dominance over him. This is easily evident in the mobile arts. A performer of a musical composition practically becomes its creator for the time; the dancer relives the ecstasy with each repetition. This is, however, just as necessary in the static arts. To see completely a statue or a painting, the spectator must become the vicarious creator for a while. The fundamental processes I shall label: *Eurythm, pose, poise, grace, personality, vision.* From their nature these are not the names of intellectual processes. They represent purely spiritual structures, living, changing, quite vague from an intellectual point of view. They are branching lightning-trees, lunar rainbows, vanishing ribbons of the auroral lights, lilies blooming out of the nebulous clouds over a mountain-top. But these spiritual structures are among the most real entities the human creature will ever find.

Eurythm will mean that phase of the creative spirit which leaves its stamp in the quality of a production called rhythm. Without eurythm in the spirit no rhythm would appear in the production. It is a directive agent, the inner pulse-beat, the cosmic wave of the spirit; for spirit palpitates even as matter or light.

Pose will mean that phase of the spirit which leaves its record in what we call design. It is the directive agent which places space-forms, time-forms, number-forms, color-forms, selecting the patterns they should exhibit.

Poise will mean that phase which directs the production of symmetry. The spirit must balance itself before it can create outward balance. It is the creative act of weaving threads of life into a net of symmetry, however intricate.

Grace will mean that phase which produces harmony. In the sway of its control the parts of a production fit together, are consistent, complementary, sympathetic.

Personality will mean the centralizing phase which keeps everything organic, unitary. It is the quality of identical persistence of the spirit.

Vision will mean the phase of the spirit which sees things not yet actual, which creates new spiritual forms to have expression in some medium. Without vision art would be impossible.

After a work of art has been finished, particularly in the static arts, it may then be made the object of intellectual study and criticism; but this is no more a study of art than the determination of the Fourier series for the crinkled groove in the phonograph disc is a study of music. The art is not in the statue but in the act of creation which gave birth to the statue. In this act must be found the reality.

Man is not entirely the product of "evolutionary" forces, for he has always defied the world that environs him by attempting to bend it to his will. Whatever his method of doing this and whether successful or futile, it shows clearly that he knows himself to be a creator, even though the material out of which he must

actualize his dreams as best he can is ill-adapted, inadequate or refractory. At times he is only too conscious that he is a leaf whirled in the eddying gust, but he has never accepted this fate. His very study of his environment is partly due to a gadfly curiosity, but it is due just as much, perhaps more, to his intention of becoming the master of the world, making it subservient to his wishes. For what? More food and clothing? More possessions? It takes little observation to see that these are usually secondary. What he is after is spiritual power: power to carry out his ideas, power to prove himself a builder, to give outlet to the seething forms that emerge far down inside him, in that inner life which is his most real life, the life that would be bound, inert, inactive, ineffectual, unless he acquires power to put it into some expressed form. He finds that outlet in creative activity: he may do it in the dance for rain, he may do it in Hamlet, or he may construct a slender stem holding a flower high up above the arid city street. Though he be tossed by the winds of destiny, though he may float on the river of heredity, he is not content with this. He is also an individual, something unique in the universe, and he has within himself an urgent inner life which must be let loose. He finds at times that his environment is too much for him, and he makes himself passive to influences outside his control, so that he may study them carefully, keenly, to penetrate their secret structure and to learn in what way and to what extent he can turn their turbulent currents into channels of his own. He develops his analysis of them, his imagined laws, his system of science, his constructs, finding within himself what matches them, so that he may go with them long enough to get command of them. But he knows intuitively that his place in the universe is not that of a mere spectator, seeing things only by "flashes of lightning,"[1] the rest all darkness and mystery. He is not a beggar-child looking wistfully through heavy plate-glass at the feast of the universe. Neither is he a walking-doll that says "mama" and goes to the ash-barrel when the mechanism is broken. He is an adventurer who is out on a quest of beauty. There is inside him an incessant longing—not always consciously known,—but yet persistently there—for an invisible, intangible, inaudible reality, which is more important to him than all the trumpery with which he may surround himself, for this reality is indeed himself. It is a glorified expression of that which he sees himself potentially to be. Whatever means of expression he finds will be as inadequate to express his vision as the paper and ink to carry an impassioned lover's rhapsody.

When the first primitive tribe with sweating labor managed to stand on end a huge monolith, their expression of the majesty and power of their first vague intuition of the unknown, expression of their own dim consciousness of capabilities, of powers to be attained only in the tedious march of centuries, a monolith reaching up higher than they, solid and undisturbed by rain or frost, was there nothing real and permanent for which this clumsy symbol stood? Even the archeologists and ethnologists who see in it nothing but a phallic symbol will have to admit that the insurgency of life and the urge to creation are worth a symbol which shows them as eternal realities.

The two-fold character of the psyche is easily evident with only a small amount of reflection and very little insight. There is the ability to crystallize the evanescent and flowing waves of events into definite and stable forms, and this is called knowledge. Then there is the constant urge to create new elements, more spontaneity, unguessed and undreamed forms for the inner life, and this is called art. So fleeting is the configuration of the psyche that the fixed and stable elements are ascribed not to

[1] Poincaré, "La valeur de la science."

it but to an objective world which is assumed to be independent of the psyche. Knowledge is assumed to be understanding of an extraneous entity. Art is assumed to be mere play of the spirit, fleeting emotion, of only passing interest. Both assumptions are wrong, since knowledge is the more or less temporary system of invariants with which the psyche plays, while art is the emergence of the new life-forms of the psyche itself. Those creations of the psyche which it retains for a while constitute knowledge, and the creating of a new form is art. It is easy to restate knowledge since its forms are for a while permanent, but to state art one must accompany the wild duck in its flight, must freeze the rainbow the sun produces against the shower of events. This means of course that knowledge and art are human, even if they plumb the absolute. What sort of psychical material a Martian cherishes as knowledge we can not know. What sort of art he creates we can not know either.

The stable routes from one item of knowledge to another we call logic. They seem to us to be necessary, but merely because we have made them habitual in going from one judgment to another. To find other routes would be an act of creation, which would be art, not logic, and this process of making new logics is actually going on. Stable modes of art would be impossible, since creation implies the unexpected, the versatile, the ever-new. This does not mean that in the creative process there is not a permanent reality. Reality does not mean fixity, crystalline structure. Any organism that maintains its individuality as an organism, even though subject to a steady flux of material, even if every atom, material or mental, is changing momentarily into a new atom, is nevertheless a reality. The human body is a reality, the immaterial sieve through which chemicals flow. The reality of art is of this nature. An easy example is dual symmetry, both complementary phases together constituting the unitary symmetry. This may be found in positive and negative number, in geometric reflection in a plane mirror, in sine and cosine, in wave and particle, in the façade of a temple, in the right and left of the human form, in the purple and yellow of the sunset, in the assonance and dissonance of music, in the earthly and the heavenly love, in male and female, in good and evil—what matter the medium in which the dual symmetry expresses itself? The reality is that which generates the symmetry; the forms are adventitious. The stable *idea* of symmetry is knowledge, the *actualizing* of symmetry in some form is art. Indeed knowledge and art are phases of a dual symmetry in the psyche itself, though there are also to be found trinities, quaternities and many other forms. The struggle of the poise of the spirit with its medium of expression is often intense: "white, white blossom, fall of the shattered cups day on day."[2] To many of the realities of art there do not correspond ideas; they are not expressible in the abstractions and static forms of language. The nearest approach in language is in creative, metaphorical, suggestive poetry. Hence stating an example in words is very inadequate. It is at best a sort of ticket for reality itself. "Art is the very flowering, the tangible flowering, of the creative soul come to ecstasy."[3]

There is a constant interplay of the two characters of the psyche. It is the creative character which furnishes knowledge its hypotheses, the most steady source of advance in science. It is the crystallizing character which furnishes art its types of expression, the most steady source of production of art works. Research goes on all the time both ways. On the knowledge side it usually consists in an increase in dispersive power, splitting principles into more universal prin-

[2] J. G. Fletcher, "White Symphony."

[3] S. Cheney, "The New World Architecture," p. 347.

ciples or more fundamental hypotheses. On the art side it usually consists of experiments made to find a more adequate method of handling the medium, expressing more fully the artist's vision. Often the apparently unrelated researches spring from the same source deep down in the psyche. It has been pointed out that much modern art is an actualizing in art forms of the same universal invariants as appear in science in the Einstein theory. Human life, after all, is unitary, and we should expect this symmetric dualism in its manifestations. When crystallizations made by the psyche no longer fit experience we have an advance in science. When forms used for art no longer convey the message of the artist we have an advance in art. Neither advance is welcomed by the multitude, for the usual human being is Faust, always seeking the moment he will bid to stay because he has found his supreme desire. Man is still quite hairy with his past.

A few years ago a picture labeled "Life" hung in an exhibition. It was not large, but the canvas was a confusion of gaudy patches of yellow, green, blue, red, in chaotic arrangements and vague outlines. A bystander remarked, "Look at it! Did you ever see anything so crazy?" The reply was, "Is that a beefsteak in the center or a volcano in eruption?" Other comments were similar. Yet the artist in his conventionally jangling colors, his disorderly arrangements, his unformed outlines, really portrayed vividly the struggle of the eurythmic, the pose, the poise, the grace, the vision really inherent in the spirit of man, with the clumsy, stumbling, disharmonious unbalanced environment after the war. An erudite volume would not have made it as plain. "Art may tell a truth obliquely, do the thing shall breed the thought." "So may you paint your picture, twice show truth, beyond mere imagery on the wall,—so, note by note, bring music from your mind, deeper than ever Andante dived,—so write a book shall mean beyond the facts, suffice the eye and save the soul beside."[4]

A work of art is the exhibition of a significant form in which the creative spirit of the artist incarnates itself. Its purpose is to effect a transfer of some part of the spirit-life of the artist over into that of his public. In the static arts the flame of creativity is frozen in its flickering, but an intense moment is chosen so that the unchanging exhibition will always suggest the lambent fire. In the mobile arts a portion of the creative life is caged and placed on exhibition, and may be reproduced many times. The dance, the drama, music, mobile-color, give us a chance to live the life of the artist for a few exalted moments, caught up in his ecstasy, feel his rapture, and glimpse eternity.

> Presences plain in the place: . . . a flash of the will that can, . . .
> Existent behind all laws: that made them, and, lo, they are! . . .

until we say:

> Well, it is gone at last, the palace of music I reared, . . .
> I feel for the common chord again, the C major of this life. . . .[5]

Art is not concerned with life as life, any more than mathematics is flowering for astronomy or physics, but with that essence of life which is in the ever-changing structure of the spirit. Art is not primarily concerned with value, though values will be attached to its products, just as to the products of the intellect. It is not the function of art to moralize, but to set forth the character of spontaneous potentiality in the spirit. When he carved in stone Villon's poem, Rodin expressed in "The old courtesan" not the miserable end of a misspent life, but "the antithesis between the spiritual being which demands endless joy, and the body

[4] Browning, "Ring and the Book."
[5] Browning, "Abt Vogler."

which wastes away, decays, and ends in nothingness."[6] Art is not concerned with penalties but with creative expression. It seizes and passes on to us the structure of pure form, the reality in spirit. Knowledge may evolve from stage to stage, but art can not evolve. It expands, flowers in new blossoms, creates new universes.

Art is not susceptible of intrinsic progress. From Phidias to Rembrandt, there is movement but not progress. The frescos of the Sistine Chapel take absolutely nothing from the metopes of the Parthenon. Retrace your steps as far as you like,—from the palace of Versailles to Heidelberg Castle, from Heidelberg Castle to Notre Dame of Paris, from Notre Dame of Paris to the Alhambra, from the Alhambra to St. Sophia, from St. Sophia to the Colosseum, from the Colosseum to the Propylaea, from the Propylaea to the Pyramids: you may go backward in centuries, you do not go backward in art. The Pyramids and the Iliad remain in the foreground.[7]

The events of art are the aspirations of the spirit, and the invariants of such events are hopes. They furnish a system inherent in human life just as valuable for profound study as the invariants of the phenomenal world. When hopes are organized into a wild bird of the spirit ready for its flight, they become visions. Through the centuries these have been the dominating factor in the life of man, not the fogs of his swamps nor the rain of his tropics nor the crags of his fastnesses, nor the blue-white sun of his deserts. Through the acquisition of knowledge we attach our tentacles to what the psyche has made stable for itself. By the enchantment of the artist we receive the power of new life. Art is an offering of a sacramental communion of one personality with another.

II. Mathematics; Creator of Frost-Flowers

Sandburg said poetry is the achievement of the synthesis of hyacinths and biscuits, and we may read mathematics instead of poetry, because mathematics is the child of the creative power of the artist and the crystallizing power. Many times mathematics has created new worlds, and developed them intellectually. Some forgotten genius saw the reflection of ordinary numbers, and created negatives, opening a vista to a new infinite horizon. Then another genius saw an infinite plane of worlds of number all radiating from the central zero; and a century ago Hamilton saw this center sparkling with rays in all directions. Since that time the worlds of number have become infinitely numerous, and the intellect has work for centuries. When the school of Pythagoras stood appalled before the first irrational known, they little guessed the swarms yet to appear. When a rebellious youth named Galois looked at the roots of equations, he saw they were arranged as petals of more and more intricate flowers, each made from the conjugate sets of roots of special resolvent equations, each conjugate set generated by a single irrational, the whole furnishing a glowing corolla, a unitary work of art. They were like sets of dancers when the group of the equation began to act, going through patterns tangled but describable in terms of a few fundamental changes. The defiant quintic was tamed, and its twelve pentads, or twenty triads, or thirty dyads, connected together, gave all the recurring cycles of the dance. Some day we may see a Ziegfeld producing the "Dance of the Quintic."

When Lobatchevsky created a new world of space it did not take long to create many other new worlds of space, worlds bizarre to common sense. They furnish hundreds of crystallizations called theorems, and have even suggested to the scientist better patterns to hang his phenomena on. Four-dimensional geometries and others have appeared, full of latent possibilities for new designs for artists. Indeed, much modern art is based unconsciously on such space harmonies. They spring evidently from a common

[6] Rodin.
[7] Victor Hugo, "Shakespeare."

source, though expressed in art forms or studied by the intellect.

Bernoulli created expansions of functions in powers of the argument, and later Fourier in series of trigonometric functions, but they did not see the host of new and startling functions thus born into the world. Their successors created more worlds of functions, and the day came when one such world called "wave-mechanics" was all that was left of a definite character in modern physics. The linear operators which furnish these expansions are intellectual forms which arise in the living transformations of the spirit itself. Under their magic we see the world of matter bending into new shapes, and even if it is an inanimate world these forms have an intrinsic beauty of their own, which is what fascinates the physicist. The study of these operators shows that while change may be expressed in an infinite and continuous series of manifestations, yet in the changing itself there may reside a permanent and stable essence, the structure of the operator itself, which is ultimate reality. We finally see the entire collection of different instants simultaneously, just as we visualize a differential equation by its field of characteristics, or just as a musician can grasp a whole symphony as a single unit, a timeless form. The futurists undertook to do the same thing in painting for motion, presenting together a succession of different experiences, thus suggesting the unified experience as a single undivided whole.

Kempe defined mathematics as the science of pure form, and C. S. Peirce as that subject which studies ideal constructions. We might then be tempted to consider all art as consisting of branches of mathematics. There would be some justification for this in much modern sculpture, painting and music. But we must not forget the distinction pointed out at first, between the two modes of knowing, one studying the crystallized product, the other the process of creating. Mathematics makes pearls, art living tissue. Artists themselves are sometimes confused as to what art is, when they neglect this distinction. If one studies the forms created by musicians he is not then an artist. He might write a quite mathematical treatise on the subject. Neither is he a musical artist if he merely gives expression to what has already appeared in a different form.

It is the function of the intellect to examine the cold product of the artist, and such study may deceive the student into thinking he is studying art. It is the function of the intuition to seize the essence of the creative act, to experience directly the thrill of creation of course, but in the rich complex of emotions to perspicate that which is not emotion nor thought, but a permanent and abiding reality, the very essence of the spirit as it dissolves into a new seraphic body.

The question whether mathematics is true, or whether a work of a painter, poet, sculptor, musician or dancer is true, is without much meaning. All it can mean is an inquiry as to how far the form of expression chosen adequately conveys the artist's dream. For instance, Riemannian geometry is true, so is Euclidean. They are both creations. A Gothic cathedral is true, so is the Empire State Building. The Moonlight Sonata is true, so is the Rhapsody in Blue. One does not ask whether an orchid is true, though it does not resemble a lily-of-the-valley. Both are expressions of creative energy. One of the delightful qualities of art is the variety of ways in which the same ultimate reality may be expressed. All the art, all the mathematics, all the science in the world could be destroyed, and humanity would start the next day to produce more, very likely utterly different from what has been before, but yet just as true. The reality in mathematics is in the spiritual energy locked up in its crystal-

line flowers, and if they melt in the sun, the same energy will flower anew in other forms.

III. Poetry: Creator of Silent Songs

Sea-violins are moving up the sands,
Curved bows of blue and white are flashing over the pebbles;
Hear them attack the chords: dark basses, rising trebles,
Dimly and faint they croon, blue violins.
"Suffer without regret," they seem to cry,
"Though dark your suffering, it may be music,
Waves of low sound that wash the midsummer sky,
Sea-violins that move across the sands."[8]

Poetry is twin-sister of mathematics. Mathematics is wordless poetry, and poetry is mathematics in words. Both are essentially independent of the senses, though both use visible or spoken symbols as a means of communication. While mathematics talks largely in terms of concepts, poetry talks largely in terms of memories and images. The use of any kind of language is symbolism, so both use symbolism. Both speak in metaphors, for the particular statement made is pregnant with meanings not stated.[9] The significance flowers and fruits continually long after the first statement. "Poetry is the arch from inspiration to appreciation."[10]

Poetry is somewhat more concrete than mathematics, its symbols more associated with actual living. In the quotation above the endless beating of the sea, the distant horizon, the flashing blue and white, the music of the waves, the overarching sky, are symbols full of meaning to those with experiences. The endless beating of the years, the mysterious horizons whence time emerges, the aspirations, the defeats of the days striking against the hard unformed facts of life, are rich to those who have lived and open far vistas to the young.

[8] John Gould Fletcher, "Black Rock," p. 90.
[9] *Cf.* Scott Buchanan, "Poetry and Mathematics."
[10] Claude Chauvière, "Colette."

Is it necessary to repeat the reality the poet is living as he sings? This reality is the underlying music, the symphony which human life may be, despite the daily monotony, the petty swash of the environment, the apparently inert pebbles played on by the ocean of circumstance. Is this symphony any less reality than the ceaseless whirl of nebulae or the pulsating ultra-microscopic fogs called electrons? Is it any less important to point it out with an accompaniment of emotion which will carry it into the lives of the readers as an effective force, than to quote the latest cold statement about the supposedly expanding universe? Since the poet states his vision in words, can we argue that the artistic form is unnecessary? Not at all. The stark philosophic statement has no living appeal, is abstract, is part of an argument which proceeds in straight lines to a conclusion. The poetic statement is "a succession of curves, the direction of thought is not in straight lines, but wavy and spiral."[11] There must be rhythm, order, symmetry, harmony, unity and ideality, themselves due to the characteristics of the spirit when creating, as mentioned above. The technique of the poet is part of his art. If spirit knew how to pass its creations consciously directly to other spirit, technique and media of expression would be unnecessary. The abstract words alone fail to convey the full message of the poet. Abstraction gives at best a gauzy illusion which simulates reality. Intellectual comprehension is an anatomist beholding a corpse. Intuitional appreciation touches the living body.

What the artist does for us is to grow an evanescent flower, blowing but a moment, fragile, yet the focus of an intense creativity. If the poet can so assemble words that they catch us up into a whirl of intense flame, make time cease to be, external things to vanish, open an illuminating insight to distant isles, emerge an

[11] J. G. Fletcher.

ecstasy to carry the spirit up and up, until life, the world, the self, everything is seen by a supernal light and from a sublime height—then he is a perfect artist. The limitations in doing this by words only are heavy, the butterflies are weighted down by their wings, and even after these many centuries the poet has not yet full command of his medium. New visions appear and new modes of writing poetry must be discovered. The modern poet is not transcribing emotions nor depicting bits of raw experience, but is incarnating in a body of words those spiritual forces which are creating new organisms out of the life of to-day, welding together new groups of humans, evoking a new civilization, a new humanity which is not going to be crushed by the machinery and the financial systems of to-day; new forms of personality capable of dominating the enormous material power turned loose in past decades; victorious spirit flying freely over the maelstrom of seething energy, and in the cyclonic whirl of disorganizations generated in the chaos of war. Are there realities in art? The artist sees only realities —realities which would drive man mad, gaunt demons that haunt his soul, grinning gargoyles that look out over the tragedies in the city of civilization, insidious specters floating over the landscape bringing woes and desolation: realities that man himself creates day by day, wittingly or not; and also realities that have the serenity of gods, joyful Ariels of adventurous youth, triumphant angels of a transfigured world. We are in a creative renaissance, and one must expect the dream-intoxicated artist to find queer unusual forms for expressing his coruscating life.

I was taken and enveloped in a cloud,
Winds awoke and called me far away.
Now I wave a veiled farewell
To the lands I knew and loved,
To the crimson sunset, resting far off on black mountains,
When there rises the full moon
I shall sail rapidly in the waning light,
Hearing underneath me the swift billowy rush of spray.
But the white cloud, milkily crested,
Shot and throbbing with pale fire,
Whirls me over infinite oceans
Which the gates of back-flung sunset let escape.[12]

Drama: Creator of Invisible Rhythms

Poetry steps out on the stage in human form, and becomes a mobile art, the drama. Tragedy, comedy, religious ritual, the first expression of man's religion, expanding through the ages into what we see on the modern stage, commercialized, cheapened, degraded, occasionally ether-realized, it remains a great art. Much of the stage production to-day is of course relaxation from the hurly-burly of present-day life, taking us out of ourselves for a little while—and indeed that is one thing art is for—the drama may point out serious problems in morals, may initiate us into forms of life beyond our reach, may take the place of the church, may be the only means of recreation, but it is none of these as a work of art: as art it is a complicated form in which we see expressed deep realities of the artist's spirit, those cadenced or broken eurythms accompanied by passions. This becomes evident in some of the modern abstract theatric art, often assisted by the other arts to produce a complex form. "Pelléas and Mélisande" in proper settings, with Debussy's wistful music, brings mystery, exquisite beauty, meaning too deep for words. "The Beggar on Horseback" with its dream-like character, fantastic stage-setting and lighting, and acting not meant to be realistic but metaphoric, expresses an innate beauty which is hinted at in the inset pantomime. "Lysistrata," recently shown in very unconventional setting and acting, purposely exaggerated in some ways, presents a fine example of Hugo's remark that art never grows old.

[12] J. G. Fletcher, "Black Rock," p. 16.

Though they may appear startling, daring, shocking, fantastic, unreal (whatever adjective may be used to indicate that the soul has been stirred out of drab monotony), modern theatric art will no doubt some day culminate in a work of supreme beauty, holding immense audiences breathless, spell-bound, silent, swept out of time, infused with new eurythm, seeing the spirit in a new pose, with new poise, full of grace, abounding personality, and with a vision of a glorified new life for man.

IV. Architecture: Creator of Musical Crystals

Architecture is an art far removed from the subtleties of mathematics and poetry, for it deals with matter directly in great masses, grouped into buildings, usually designed for utilitarian purposes. Here artist and engineer meet, and lately the engineer has been the artist. We might pause to consider whether architecture has the character we have insisted upon, expressing realities of the human spirit. But it becomes evident that we do have a definite reality appearing here, which may be called the timelessness of the spirit. The human race has always felt that there was an indestructibility in the spirit, and it has tried to express this in towers of Babel, pyramids, gardens of Babylon, temples, cathedrals, tombs. If man were really convinced that he is but a bubble poured by the Eternal Saki, he would live in any kind of shelter that would answer his needs. He would have no incentive to contrive architectural beauty. But he knows himself as outside the flux of time, he feels his power to build things that will last, since he has himself the lasting quality, and his architectural products are symbols of that which is inadequately called "his character." In his buildings he leaves a record for his posterity of his aspirations.

Louis Sullivan says:

> Men have ever felt the need to build. As they built, they made, used, and left behind them records of their thinking. Then as through the years new men came with changed thoughts, so arose new buildings in consonance with the change of thought—the building always the expression of the thinking. Whatever the character of the thinking, just so was the character of the building.

The architecture chosen for the world fairs of to-day exhibits the character of to-day. The new "sky-architecture" of America is an exhibition of the new life appearing in the western continent. It is organic, arising out of the purpose it has to fulfil. It is simple, stripped of convention and useless ornamentation. Life has become that, conventions are dissolving, artificial taboos are laughed at, and modern life in every way is becoming more naked and unashamed. The steel girders which support life are left visible, glass walls let light into living, and also show the world that what goes on inside is nothing to be hidden. Modern architecture represents downright honesty and simplicity. By the lavish use of color and lighting effects it expresses the joy in living. It exhibits those hidden realities in the spirit of man which we call organizing power, dominance of mind over matter, arrest of decay. So far as it transcends the organizations of the past centuries it points out the essential character of our new civilization of frankness.

Most of us recall the marvelous dream of Eliel Saarinnen for the building which should have represented the modern newspaper as the daily expression of the life and dreams of several millions of people. Perhaps the present building does that only too well! Is the poet right when he says:

> Though food be scarce and drink be lacking, though labor be in revolt and trade be declining, America will go on finding its visions in the mist that hangs unstirring, though through and beyond it come the loud crash of waves shaking the granite, beating like inexorable drums of fate, sounding boom on boom;—each one a minute-gun to mark the years that must elapse before the moment of its doom.[13]

[13] J. G. Fletcher, "Breakers and Granite."

We may have hope, however, when we survey the newest architecture, mammoth and massive as Arizona buttes and canyons, or slim and straight as it soars into the sky, reminding us when in color of the everlasting rock in the desert which defies sun, time, wind, weather, petty centuries, and like the temples of the Grand Canyon, the same yesterday, to-day and to-morrow. We even feel in these structures that all the rackets, gangs, crime and rotten politics of the cities can not really destroy the life of the people, for it is at bottom mammoth, massive, rich in color and aspiring towards the light.

Sculpture: Creator of Sleeping Beauty

Sculpture uses solid material to express its vision of the realities of the inner life. It waves a magic chisel and the princess lies enchanted, motionless, until the prince appears. Sometimes it is on the side of a mountain or in a block of marble, or it may be a mass of wet clay, even a bit of carved ivory. The form may be the Sphinx, an Aphrodite of some forgotten Greek, the "Kiss" or the "John the Baptist" of Rodin, a bas-relief of Aristide Maillol, a distortion of Archipenko or an abstraction of Duchamp-Villon. But in every instance the sculptor is trying to put into the sleep of three dimensions a creation which comes from his own eurythm, pose, poise, grace, personality or vision. In different sculptors these realities may have different emphasis. When he sees man as the creator of his own body, a daily sculpture, the epitome of all principles of art, he may put into stone Browning's verses:

For pleasant is this flesh;
Our soul in its rose-mesh
Pulled ever to earth, still yearns for rest.

Let us not always say
Spite of this flesh today
I strove, made head, gained ground upon the whole.

The sculptor realizes that the body is itself a manifestation of the spirit, the creator which organizes chemicals into human forms. So he has typified thousands of times in his statues of man and woman, strength, power, defeat, vague aspiration, sheer loveliness. The dancer is arrested in her pose, yet showing the rhythm, with the moment before still warm, and the moment to come heard breathing. The sculptor does not make dead things, his statue is sleeping, not lifeless. Presently it will stir, and new life will emerge from the dreams of that sleep. He chooses a significant sleep so that the great fundamental invariants of spirit may be seen when in transitory motion they might be missed. He uses his masses to convey properties of life; life caught for a moment in repose, one phase of the rhythm ever present. And when love inspires Pymgalion Galatea shall awake.

Painting: Creator of Singing Light

We lose solidity in painting, though we may create the illusion of it, but we gain the subtlety of color, and the chords of color we may strike from the prism. The gain is at the risk of a sense-reality which may hide the spirit-reality that the painting is to exhibit. A painting may copy nature or some aspect of humanity so faithfully that it is deceptive, and we catch the scent of the flower in the field and start to speak to the person. It may even become a perfect anatomical or psychological study. Then its external reality is a will-o-the-wisp to lead us into the swamps of the subject. This is so great a danger that some modern painters have avoided painting any subject at all recognizable. Also the scene depicted may stir our sympathies or our memories, and we tell ourselves a tale, jovial or heart-breaking. This is perhaps the function of the novelist, but it is not what painting is for. "The Rake's Progress" may be a good sermon, but it is not for

that reason good painting. Then again a painter may have such extraordinary skill with his brush and palette that he imitates flesh or tapestry almost perfectly, but mere dexterity does not produce a work of art. It may make a shadow photograph in color which reminds us of the original and which we love to look at and to live with. But this is not the purpose of painting.

If one studies the wonderfully flowing lines, the balanced curves, the unified composition in Georgia O'Keeffe's "Lake George" he cares little what lake it is or if it is a lake at all. In her "Cos-Cob" there is no intelligible story, but the masterly placing of musical ripples and flowing winds is a study of the eurythm and the grace of the spirit itself. And in her "Music—black, blue, and green" she has made the spirit itself visible in an act of creation, in color and composition that sings. In these paintings there is little to distract us from perceiving the reality. We have a view of beauty herself veiled in diaphanous gauze. In the last-mentioned there is even a glimpse of ecstasy, an all too rare reality, yet vividly real and abiding once attained.

The painter uses colored spaces and lines of drawing, but they are passed through the magnetic field of his esthetic personality and come out curved into more than color and line. There is added what artists call "the fourth dimension," a term borrowed from mathematics. The forms are idealized in a sense similar to the mathematical sense, not in the ornamentalizing sense. This kind of idealization is a perspication of the essence of the form, and vivifying it into a body for the spirit-reality. When this takes place it may happen that there is introduced a distortion from what would be expected in a naturalistic, unidealistic painting of "things as they are." But this is often necessary in order to produce the expression desired. Whatever one may think of paintings in which parts of objects, geometric figures and other fragments are placed in queer positions on the canvas, after all it is not very different from the mathematician's various projections of a four-dimensional object, itself a unit to be synthetized from its projections.

The highest outcome of the progress of painters in handling color is shown in "Synchromy," an attempt to express by color-compositions with no definable shapes, the realities of the artist's spirit. Morgan Russell's "Synchromie Cosmique" is an example. He says of it "a spiralic plunge into space, excited and quickened by appropriate color contrasts, is designed to get rid of definite objects to intensify color rhythms, and thus emphasize the innate beauty." When one hears these songs harmonized on the melodies of light, he comes to the very spirit of beauty. He might intellectualize them and would find therein a structure very like many things already in mathematics; and he could state theorems and might thus convince the intellectual critic that they surely hold reality. But a wild rose is something more than a dihedral group of order ten, and synchromy is more than a kaleidoscopic moment. The spiralic plunge into the scarlet mockery of weakness, gray midwinter and dead dreams, violet memories, green pastures, orange conflicts of the spirit with itself, black whirlpools of struggle and failure flecked with golden sparks of illusions, out into blue depths and mysteries, through the golden city of art, to the white unattainable perfection,[14] swept along on the cosmic winds—shall we reach the ultra-violet ecstasy the spirit passionately longs for?

Color-Music: Creator of Rainbow Phantoms

We are led inevitably to the consideration of the orchestration of color just as

[14] See preface to J. G. Fletcher, "Goblins and Pagodas."

sound is organized into music. The clavilux and similar instruments for the production of mobile color, one of the newest arts, has been made possible by the development of electric lighting in all its forms. Before a performance of this organ one sits in silence, entranced by a new world, space and time have vanished, old ideas are gone. We see the birth and vanishing of creative forms in marvelous colors, almost actual spirits. It is a cosmic art, for it has flung a net over the Aurora, the only thing nature produces like it. It is very complex, for there are tints corresponding to musical tones, but of a far greater range of nuances. There are values for which music has no counterpart. There are intensities, color melodies, polyphotic effects, counterpoint. When we have many such instruments combined into modern simultaneous art we might conclude there is no art superior to this. It carries all possibilities of abstraction, all the spiritual qualities of light itself. It does not represent objective things. It is the essence of esthetic. There are no copies of nature, however lovely; no story condensed to the simplest tabloid; no suggestiveness by hinting at something unseen; no symbolism for something else. We have sublimated art with no background to distort our vision. We have the unique experience of the wondering child seeing his universe as a fresh, living, changing meadow of flowers. We witness the first act of creation under the command, "Let there be light." And there is light in many senses, for in the study of these rainbow phantoms we come to see in an unobstructed view the kind of reality the artist is setting before us, a new sort of mathematics indeed, with its very distinct and vivid spiritual fusings that take the place of material relations. Some day there will be written the great treatise on "Harmony and Counterpoint of Color-Music," an account of the structure of intoxicating beauty of the most spiritual kind. And a coming Beethoven will create symphonies surpassing anything the world has yet seen.

V. Music: Creator of Ethereal Flowers

Boom! and the deep-toned note of the big bell drifts away under the curved roof of the temple, and ripples against the golden curtain. Clang! from all the gongs, and the golden veil is rent, disclosing a "naked, rose-empurpled god, rippling with crimson-violet light."[15] The artist feels something has been born of him. These instantaneous waves of sound in a harmonic instant give a picture in tone. They are static, but they awaken echoes in the soul from both past and future. Music itself, however, is not static; it is a mobile art given to the world centuries ago when man learned how to control sounds long before he learned how to control light. Music was bound to come as the natural outlet of the eurythm in his spirit, though the first great art was dancing.

"The secret of music is the secret of all art."[16] It is called an abstract art like mobile-color. There is no subject-matter, it tells no story, there is nothing objective save a few unguessed ripples of invisible air. It passes away with the playing, can not be placed in a museum, nor hung in a salon. It shows very clearly the synthetizing power of the psyche, for it consists objectively of nothing but sequences of many simultaneous sounds, yet these are organized into a single unit. The entire composition, however much time may be necessary for its execution, is a single work of art. Then too the spirit of music, even more subtle, is not in the sounds at all, but yet is the essential part. Hence it may be called an abstract art, but that does not mean intellectually abstract. Musicians mean the opposite of sensuously concrete,

[15] J. G. Fletcher.

[16] Colin McAlpin, "Hermaia."

and esthetically abstract, not philosophically. Yet because of its very tenuousness it appeals to more persons than any other art. Plato says: "Music gives soul to the universe, wings to the mind, flight to the imagination, a charm to sadness, gaiety and life to everything. It is of the essence of order, and leads to all that is good, just, and beautiful, of which it is the invisible, but yet dazzling, passionate and eternal form."

Music is the expression of such profound realities as personality with its thousand fascinating varieties, persistent, free, creative and immortal, the phoenix ever rising from its ashes. These are infinite terms whose content has been declared to be nil. But in this art we find direct experience of these realities, not as concepts, constructs nor conclusions. Music represents the continuity in spirit, its fusion with other spirits, its intuition of itself as individual. It is the complete expression of pure personality. It is the expression of the ineffably divine. It is the expression of our awareness of the spiritual universe in whose ambient atmosphere we live and move and have our being. In music man expresses his appreciation and understanding of his ultimate goal. This explains the intimate mixture of music and religion, whether we find it in Brahms or in Gounod. Music is a power which lifts us on the wings of aspiration into that empyrean whose crystal air and ethereal light is beyond all reach of the transient, the phenomenal, the ceaselessly changing and vanishing. Through music we reach the world of truth which the mystic finds, "even as the waters of the infinite ocean send their waves to break among the pebbles that lie upon its shores."[17] Consider the prelude to Lohengrin. It has been said that Beethoven wrote the Ninth Symphony to exhibit the existence of God. Beethoven himself said his Sonata Appassionata was Shakespeare's "Tempest."

[17] William James.

Like all arts music has expanded and tried to get away from conventions and canons whose only source of authority is their age. It has attempted to find more freedom in new ways of expression so as to set forth profounder spiritual realities. The names of Stravinsky, Schoenberg, Varese, Casella, Falla are well known, even though they have not accomplished all they had in their souls. Back of these are Strauss, Debussy and Ravel with others. They have tried to produce sheer music, free from the usual attachments, symphonies corresponding to the synchromies of the painter, with the added dimension of time. Whatever the music of the future may be with new modes of expression we know that it will be powerful in the life of man.

VI. Dancing: Creator of Radiant Youth

Pom, pom, pom, the drum is sounding, and on the hard ground of the New Mexican village the thud of dark feet, accompanied by the chant of Indian voices, is dancing the seed down, down, down, into the ground with all the transferred energy of the Indian soul to make it grow, sprout and fruit plenteously. Some day the blue, red, yellow and white grains will give back more energy. During the whole day "Winter" and "Summer" have alternated dances increasing in vigor, becoming "an organic paean of praise of life." The powerful rhythm even gets into the blood of the spectators with its movement, vibrating color and intense spiritual fire.

The stage is dim, and the black velvet curtain at the back hangs in long folds that lead up into the top. There glides out upon the boards a piece of floating thistledown, which begins to weave patterns in the spotlight, back and forth, in graceful curves, a body as flexible as a wisp of mist.

More than the ripple of grass and waters flowing,
More than the panther's grace,
Or lily moved by winds from sunset blowing, . . .

An evanescent pattern on the sight . . .
Beauty that lives an instant to become
A sister beauty and a new delight.

Through you the past is ours,
Through you the future flowers,
Through you we find again
That birth of bliss and pain,
That thing of joy and tears and hope and laughter
That men call youth.

Dance on, translating us the mortal's guess
At Beauty and her immortality,—
Yourself your flesh-clad art and loveliness.[18]

The dance is over, the stage is dark again. Then the spirits of the aurora begin to play, formless, glowing with such color as conveys subtlety, all the intricacies of the wistful dreams of man, "the imprisoned essence of the winds, varicolored lightning, fairy forests, the laughter of spring and the golden browns of autumn"[19]—sighs, hopes, dreams, aspirations, wraiths of beauty in the making. Into the vaporous light there wind low threads of music—such music as Ravel could write for a fairy dance—and borne on the haunting strains dancers float in, drenched in color, glowing with light, and all the radiant beauty of unveiled spirit is visible, exquisite, enwrapped with poignant sound, expressed in the most perfect of all media art could use: the human body in the sway of a creative artist. Through all the music, the color, grace, shines the greatest of all reality—eternal youth. Can art surpass this in any other way?

Dancing may become again what it was originally, the expression for the religion innate in man. Here is a stage, half-way up a hill, set against the sky. The Prophetess sits brooding over the sins and the suffering of the world; below her feet the milling, toiling mob of humanity ebbs and flows, suffering, loving, hating, battling, a chaos of emotions. The Prophetess ascends to the heights invoking the higher powers. In a flash of illumination the Powers above remind her man is the child of spirit not matter. This message she conveys to the distracted masses, a little at a time, till all have joined in one great spiral praise, the dance of cosmic harmony. This is Ruth St. Denis in her new program. When will she be seen in "The Beatitudes," "Babylon Is Fallen," and "The Woman and the Dragon"? Will this be the form the church of the future will have?

Thus the dance completes the cycle of the arts, and comes back to its beginning in one of the great vortices that sweep the soul of man along the ages—the oldest of the arts, using the human body alone, the most perfect as the most difficult of media. The grand orchestral synthesis of resources of all the arts, modern dance in modern dance-compositions will give a magnificent, overwhelming, complex interpretation in art to man.

All dreams that Hope has promised Love
All Beauty he has sought in vain,
All Joy held once and lost again.[20]

For man is the gorgeous, newly emerged psyche, drying his wings for an everlasting flight through the eternity of beauty, over the ocean whose singing blue is the harmony of the spheres, following the radiant sun. The artist sees realities only!

[18] George Sterling, "To a Girl Dancing."

[19] Sheldon Cheney, "A Primer of Modern Art."

[20] G. Sterling.

WHAT IS PHILOSOPHY?

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PHILOSOPHY is seen differently through different eyes. Some see it as good. Some see it as bad. To some it is mysterious.

The good view comes, naturally, from its appreciators; the bad and the mysterious from those who fail to understand it. The blame for these latter views rests partly upon the inherent nature of philosophy—its impenetrability to the uninitiated—partly upon those professors of philosophy who glorify themselves by appearing in a cloak of mystery or who are too impatient to lead the novice step by step, but most of all upon those impatient seekers who wish in a moment what can be had only in an hour.

The darker side of the estimation of philosophy is well worth viewing. A student informs us: "The term 'philosophy' conveys to most people a vagueness and uncertainty. The layman is ignorant of its aims and the popular impression is that it is a collection of high-flown, meaningless words and phrases on useless subjects." Such a view is not without foundation, but it is a foundation of failure. The grapes are sour to those who can not reach them.

Mysterious? "Philosophy is a mysterious subject," says C. J. Ducasse. Yet philosophy is no more mysterious than agronomy, astrophysics, ethnography, seismology or any other subject with which one is not familiar. The unknown is mysterious. And while philosophy does deal with the unknown, its mystery comes mainly from ignorance and unfamiliarity.

Philosophy is good—to those who understand it. Volumes of praise testify to its value. But praise of philosophy is no proper part of this essay. Rather the aim here is to set forth a few fundamentals. Appreciation will follow understanding.

One of the most difficult questions which a philosopher or teacher of philosophy has to answer is: "What is philosophy?" "The word," a student tells us, "is one of those elusive abstractions which, rabbit-like, always barely escapes capture and definition. It means a variety of things to a variety of persons. Each man you questioned would stop, meditate and give you another definition."

A perusal of current attempts to define philosophy would confirm this student's view. The differences between definitions offered by contemporary specialists are not merely verbal—they are real. The "basicness" of these differences will be demonstrated in a moment. First, a word about method.

No attempt will be made to define philosophy—to confine philosophy to the limits of a single sentence. What follows will be a description, not a definition. Four distinguishable components are present in philosophy. A description of all four is necessary for a complete description of philosophy, even though many definers neglect, and others deny, the importance of some of these components. What are the four components? Philosophy is a kind of *attitude*, a kind of *method*, a group of *problems* and a group of *theories*. Not all attitudes are philosophical attitudes. Not all methods are philosophical methods. Not all problems are philosophical problems. And not all theories are philosophical theories.

Philosophy as an attitude and method is emphasized by Brightman and Barrett.

Says Brightman: "Philosophy is essentially a *spirit or method* of approaching experience, *rather than a body of conclusions* about experience."[1] Rejoins Barrett: "It is *not* the specific content of *these conclusions, but the spirit and method* by which they were reached, which entitles them to be described as philosophical."[2] Ducasse apparently is willing to confine philosophy to method when he says: "Were I limited to one line for my answer to it, I should say that philosophy is general theory of criticism."[3]

Emphasis upon philosophy as problems or theories, on the other hand, appears in Leighton's definition: "Philosophy, like science, consists of *theories or insights* arrived at as a result of systematic reflection."[4] For Maritain, as for Herbert Spencer, "Philosophy is concerned with everything, is a *universal science.*"[5] To this Sellars adds: "Our subject is a *collection of sciences,* such as theory of knowledge, logic, cosmology, ethics and aesthetics, as well as a unified survey."[6] Any student of the history of philosophy will testify that problems and, especially, theories are what one seeks in philosophy.

Regardless of the varying emphases, and in spite of the genuine differences, in contemporary definitions of philosophy, philosophy can be described. It shall be described as being constituted of all four components, not of any one or two alone. Let us consider each in turn.

What is the philosophical attitude? Certainly not all attitudes are philosophical attitudes. For example, attitudes of joy, of jealousy, of despair, of fear or of intolerance are not philosophical. Persons who are at times philosophical may also have these attitudes, but when they do have them they are not philosophical. The philosophical attitude can best be characterized by nine words or phrases:

Troubled, perplexed, wondering. Philosophy begins in wonder. It begins in perplexity. It begins in curiosity. There must be a problem. An untroubled attitude is not a philosophical attitude.

Reflective. Merely being confronted with a problem does not constitute a philosophical attitude. The problem must be thought about, pondered over, and a solution attempted.

Doubting, undogmatic. He who would be philosophical must be able to entertain doubts about his beliefs. Reflection without willingness to doubt accepted beliefs can hardly be considered philosophical.

Open-minded, tolerant. One with a philosophical attitude will be not merely undogmatic about his own beliefs, but open-minded and tolerant about the beliefs of others. He will give every belief a hearing, and will not condemn without reason.

Willing to be guided by experience and reason. Since, with regard to most fundamental problems, the facts are not all in, the philosophical attitude is one which is characterized by a willingness to discard present beliefs and to accept new ones if new facts of experience demand a change. By reasoning logically about problems we often find that certain of our beliefs must be given up if others are to be held. The philosophical attitude is one which accepts the guidance of logical reasoning.

Uncertainty, suspended judgment. The philosophical attitude involves willingness to remain uncertain about any and every question concerning which the evidence is not all in. The philosopher is willing to suspend judgment as long as conclusions are not warranted.

Speculative. Believing as well as doubting characterizes the philosophical

[1] E. S. Brightman, "Introduction to Philosophy," p. 7.

[2] Clifford Barrett, "Philosophy," p. v.

[3] C. J. Ducasse, "Philosophy of Art," p. 3.

[4] J. A. Leighton, "The Field of Philosophy," second edition, p. 3.

[5] J. Maritain, "Introduction to Philosophy," p. 103.

[6] R. W. Sellars, "Principles and Problems of Philosophy," p. 3.

attitude. Even though the facts are not all in, there is always an attempt to achieve a satisfactory solution in the light of the facts that are in. Tentative solutions are sought after. It is a believing attitude, without being a dogmatic attitude, that is, it is speculative.

Persistent. Philosophy is a persistent attempt to solve problems. A momentary doubt or speculation does not make a philosopher. The philosophical attitude is an outgrowth only of a long period of reflective thinking. Philosophy is a quest for understanding which refuses to be discouraged by difficulties—is "an obstinate effort to think clearly." It is not so much intelligence, as patience, which prevents the average man from becoming philosophical.

Unemotional. The philosopher is noted for his "cool calm reflection." It is a disputed point whether any attitude can be free from emotion. At any rate, the philosophical attitude is one in which emotion is at a minimum and reason at a maximum. As philosopher, one does not love or hate, like or dislike. One simply seeks to comprehend, to understand.

What is the philosophical method? It is the method of reflection. Reflection is not peculiar to philosophy, for every science must employ it also. But most sciences, in addition, employ experimental methods. Philosophy is not averse to experiment, but its problems, for the most part, are such that they do not permit of experimentation. The philosopher, like the mathematician (the most exact scientist), usually pursues his way without a laboratory, though he is quick to scrutinize the products of the laboratories of others. Being limited, thus, to the method of reflection, the philosopher ought to become an expert in it. And indeed he is. Even the method of reflection itself has become an object of his investigation, and the result is the basic methodological science, *logic*.

Details of logical methods are out of place here. It is sufficient to mention that at bottom stands an insistence upon consistency, the principle of non-contradiction. When two assertions are contradictory, obviously, one of them must be false. Again, there is the principle of implication. When one assertion implies another, it can be validly deduced that if the first be true, the second must be true also. Upon these principles is elaborated a system of "necessary truths" about method. He who is master of these is indeed a master of thought.

It is common practice for philosophers to probe their problems in two directions, which we may call *analytic* and *synthetic*. By way of analysis, they "divide up their difficulties," in the words of Descartes, and tackle each one separately—pressing it down to its ultimate premises. So important is this procedure that C. H. Langford has ventured to say that "philosophy consists in ostentation," *i.e.*, philosophy is the clarification of concepts to their minutest detail. It is the method of Socrates, who went about humbly asking questions, seeking simply to get a clear answer. Synthesis, on the other hand, is pursuit of the whole. Parts never stand alone. They are always parts of a whole. Thus, in order to comprehend a part completely, one must comprehend its whole. He cannot understand a spoke, who has never seen a wheel.

What problems are philosophical problems? To ask "How far is it from New York to London?" is not to ask a philosophical question. But to ask "What is distance?" or "What is space?" is to ask a philosophical question.

"Do you know whether it will rain to-morrow?"—a question of no philosophical importance. But "What is knowledge?"—a question most basic in philosophical inquiry.

"Is it true that all swans are white?" This may trouble the zoologist, but not

the philosopher. But "What is truth?" Here the philosopher is deeply concerned.

"Is it a fact that Caesar is dead?" or "Is it a fact that two plus two equals four?" These are concerns of the historian and mathematician. The philosopher wants to know "What is a fact?"

"What time is it?"—not a question for philosophy. But "What is time?"—a question of great interest.

"Is the shirt you are wearing the same one which you sent to the laundry?" Philosophers ignore such questions. But "What is sameness?" The philosopher would like to know.

"Are the Niagara Falls beautiful?"—a question for sightseers. The philosopher wonders "What is beauty?"

"Is it wrong to commit bigamy in the United States?"—a problem for jurists. Philosophers inquire "What is the nature of rightness and wrongness?"

"What is your purpose in reading this essay?"—a private matter. But "What is purpose?" and "Does the world have a purpose?" Upon these the philosopher ponders long.

The above samples, pairs of related questions—the one philosophical, the other not—should reveal that philosophical questions are always general. Questions concerning particular things do not constitute philosophical problems. When a philosopher seems to be puzzling about a particular, he is really seeking a general—a most general—principle exhibited in that particular.

If we are to survey with any degree of completeness the problems included in philosophy, we shall have to go beyond mere samples and to classify them systematically. For purposes of classification, philosophical problems may be divided into two important groups: those which constitute the so-called *philosophical sciences* and those which constitute philosophy as a *comprehensive science*.

The Philosophical Sciences: Philosophy contains within its broad domain several more or less well-developed subject-matters which are properly called sciences, although they have not been received by all as sciences of full stature. Each probes a basic question, the answer to which is essential to a complete account of the world and of life. Each examines a phase of experience as distinct and as fundamental as the so-called non-philosophical sciences. What, then, are the philosophical sciences, and with what problems is each concerned?

Logic, as already noted, is the science of the methods of reflection. This is the most basic discipline in all philosophy and in all science—more basic even than mathematics, which rests upon logical foundations. What principles are presupposed in valid inferences? What fallacies commonly occur in thinking, and how may they be avoided? What deductions are possible from any given statement? And how trustworthy are inductions from any specific set of data?

Epistemology is an inquiry into the nature of knowledge and truth and certainty. Close to psychology in some of its phases, epistemology ponders the problem of the relation of knowing to that which is known. Is an idea of a mountain like a mountain? It is not like it in size; for the idea is within one's head, but the mountain is larger than the head. It is not like it in stuff, for the mountain is made of granite and soil and sand and snow; but there is little of these in the normal head. It is not like it in shape; for the mountain has three dimensions, though seen in only two, and the mountain has numerous ridges and ravines, the idea only a few. It is not like it in duration; for the mountain endures for thousands of years, the idea for the flash of a second. How, then, is knowledge like its object?

Metaphysics investigates many problems, all related to the general question "What is the nature of being?" With-

out troubling to distinguish between the subdivisions, *ontology* and *cosmology*, let us review some of the many metaphysical questions: How many kinds of being are there? How can a universe be both one and many? What are the most basic characteristics of being? What is time? What is space? What is substance? What is a relation? What is a cause? What is a fact? What is sameness? What is purpose? What is change? What is novelty? Is the world determined? Is the world purposive? Is the world progressing? Is there a God?

Axiology is the science which asks about value. What is the nature of good? What is the nature of bad? What are the kinds of value? Naïvely the child thinks the candy bar good. And later, when sated, thinks it bad. Are goodness and badness in candy bars, or in the thinking? When a baker bakes a loaf of bread, he says it is good for health. Health is good for steady work. Work is good for making money. Money is good for lots of things. But is there something that is good for nothing except itself? That is, is there something which is just good, without being good for something?

Ethics examines the right and the wrong. Popular notions identify ethics with commandments: "Thou shalt" and "Thou shalt not." But no science ever commanded or preached. As a science, ethics investigates. It wants to know how to determine when an act is right. What is obligation? What is duty? What is conscience? What is justice?

Esthetics asks two questions: "What is beauty?" and "What is art?" That these two questions, often confused, are distinct is obvious. For some beauty is beauty of nature, not of art. And to some art is ugly, not beautiful. Both of these questions demand an answer. A picture may be beautiful to one, ugly to another. Where then is beauty? In the "eye" of the beholder? On the canvas? Or somewhere else? Having settled this question, the esthetician is troubled by a greater: What are the essential characteristics of beauty? That is, what is it that all beautiful objects or experiences have in common? There is beauty in music, painting, poetry, drama, sculpture, architecture, costumes, the dance, sunsets and women. All have something in common. What is it?

Philosophy of Religion is a branch of philosophy which inquires into the nature of religion. Philosophy of religion is not religion. Rather, it is a science which seeks to understand. The nature of religion—a very important factor in every normal life—needs to be understood. It is the philosopher, mainly, who grapples with this question. There are many great religions: Christianity, Brahmanism, Buddhism, Confucianism, Taoism, Shintoism, Judaism, Mohammedanism. If all these be religions, do they have something in common? Is there an essence of religion which is to be found in all? If so, what is it?

To this array of philosophical sciences, many more might be added. *Political and social philosophy* is relatively important, but with the development of political science and sociology as separate disciplines, questions of the nature and purpose of social and political organizations is being left to them more and more. *Philosophy of education*, which seeks to understand the ultimate purpose of education, is being handled at present largely by educational specialists. *Philosophy of history*, which attempts to interpret history, not merely in terms of political, social and economic processes, but in terms of cosmic processes—what is the place of the history of man in the picture of the universe—is a field yet relatively undeveloped. Other minor problems of philosophy must not detain us here.

Philosophy as a comprehensive science. The philosophical sciences do not exhaust the problems which confront the philosopher. The best known, and perhaps most

important, problems of philosophy are still to be considered. In three ways, philosophy functions as a comprehensive science: it criticizes the sciences, it synthesizes the sciences, and it is the "mother" of the sciences.

The sciences, physics, chemistry, biology, psychology, sociology, astronomy, etc., stand in need of *criticisms*. These criticisms are of two sorts: criticisms of presuppositions and criticisms of conclusions. Each science makes presuppositions which, if examined carefully, may be found to be untenable. To philosophy falls the task of careful examination. Again, each science makes presuppositions which, when compared with the presuppositions of other sciences, may be found to contradict them. And each science eventually arrives at conclusions which, when compared to the conclusions of other sciences, may be found to contradict them. To philosophy falls the task of comparing assumptions and conclusions.

There are many *presuppositions* which scientists naturally and normally make. Some examples: Things exist in space and time. The objects of knowing are independent of their being known. Relations exist. Facts exist. True belief is possible. Things are really separate. Assumptions so obvious as these commonly pass unquestioned. But at times trouble appears because of them. The problem of examining them for the sciences becomes the concern of philosophy. Also, when different sciences make contradictory assumptions, philosophical problems arise. So long as a scientist keeps within his own field, he encounters little difficulty. Being occupied by the troubles with his own details, he usually fails to discern the implications of his assumptions for other fields of science. An illustration should make this clear:

Physicists, biologists and psychologists tend to assume that every effect must have a cause. That is, nothing can happen without being caused to happen in the way that it did happen. A body falls toward the earth instead of away from it because of gravitation. One's eyes are blue instead of yellow because of definite hereditary structures. A child is afraid of cats because he has been negatively conditioned by previous experience. For these sciences, the "law of cause and effect" holds universally.

But jurisprudence, ethics and religion, on the other hand, presuppose the contrary. That is, not everything must have happened in the way that it did. People are free to choose. They are presented with alternatives. They may select the one or the other without inevitable compulsion. Punishment is inflicted on the assumption that the law violator deliberately chose to violate. The young and the insane are exempt because they are not normal ethical beings. But the normal man is free to choose. If this were not a basic assumption, surely our laws would be written differently. Ethical codes are founded on the belief that a man can choose to follow them or not. He can do right, or he can do wrong. If it were not so, no man could be held blameworthy, and no man could be immoral. Few are the followers of Socrates who said, "No man can do wrong voluntarily."

Religious salvation is a matter of willing. "Believe and thou shalt be saved." Heaven and hell are alternatives. The sinner must choose. But *which* alternative is a matter for him alone to decide. His will is not determined. Here the "law of cause and effect" is neglected, ignored, denied.

Allowing for exceptions which occur to the alert, it is still true in general that these two contradictory assumptions are basic to different fields of explanation. Such a contradiction can not stand in a final picture of the world. No science is complete which can not fit itself into the conclusions of other sciences. To make this clear is one of the difficult tasks of philosophy.

Conclusions of sciences, like their assumptions, occasionally contradict. In

mathematics it is an accepted principle that $1+1=2$ and that $1x+1x=2x$. By reflection alone the mathematician arrived at this conclusion.

Physicists have chosen an experimental method to determine the speed of light and have concluded that approximately 186,300 miles per second is the fastest possible speed. Now if light waves are traveling in two opposite directions from a source, at what speed are they separating? At the speed of light, or at twice the speed of light?

Whenever contradictions appear, they must be resolved. When they involve one science alone, the difficulty is called scientific. When they involve more than one, the problem may be called philosophical. Thus, both with regard to assumptions and conclusions, philosophy functions as a criticizer of the sciences.

Synthesis is the second function which philosophy performs for the sciences. Each science dwells on one phase of experience. Each does its part. But where there's a part, there's a whole. To know a part only is to have a distorted view. The final goal of science should be to understand the whole—to see the picture complete. Philosophy, as a "science of sciences," as a "supreme science," as a "comprehensive science," seeks constantly to perform this function.

"The object of philosophy," says C. D. Broad, "is to take over the results of the various sciences, add to them the results of religious and ethical experiences of mankind, and then reflect upon the whole, hoping to be able to reach some general conclusions as to the nature of the universe and as to our position and prospects in it."

"Philosophy," for Whitehead, "is not one among the sciences with its own little scheme of abstractions which it works away at perfecting and improving. It is the survey of sciences, with the special object of their harmony and of their completion.'"[7]

[7] A. N. Whitehead, "Science and the Modern World," pp. 126–7.

Who has not heard the story of the four blind men of Burma and their visit with the elephant. Upon returning from their venture, they compared conclusions about the nature of the beast. Said one, who had felt the elephant's leg, an elephant is like a tree. Another had grasped the tail and reported an elephant to be like a rope. The trunk was traced by the third, who insisted it was much like a serpent. The other had stretched on the elephant's side and likened him to a barn. When a scientist insists that the whole universe is like the part which he investigates, he is to be compared to a Burmese blind man. We might have the separate reports of all the sciences and yet not see the whole elephant. In order to comprehend the total scheme, the function of synthesis is necessary.

As *mother of the sciences,* philosophy has had a long and interesting history. At one time there was no distinction between philosophy and science. Gradually, as the reflections upon problems became increasingly complex and as special techniques were developed, specialists limited the range of their inquiries, and sciences were born. Among the first were mechanics, mathematics and astronomy. Among the latest were psychology and sociology. The romance of the maturing of these offspring of the fecund mother must be left to the history of science. Deeper concern is felt for those yet unborn—the philosophical sciences which have not yet been granted independence.

Wonder about bearing children gives rise to speculation about philosophy's future. Will the philosophical sciences become, one day, sciences in their own right? If so, will philosophy's task be done? Will she become barren? Or will there be new conceptions now unsuspected? Optimism about her future is expressed in the following paragraph from Perry:

As the sciences have settled area after area of his original domain, the philosopher has pushed on to the outer edge of things. The physical

> frontier, we are told, has ceased to exist—so far, at any rate, as America is concerned. There is no more free land. But the passing of the intellectual frontier is not in sight. There is plenty of free land beyond the areas which religion and the sciences have fenced and cultivated, and brought under the rule of law and order. The philosopher lives on this frontier and makes crude charts of the region which lies beyond. In the nature of the case, the mass of mankind must remain in the settled communities, while the pioneers must be few and sparsely distributed. But it has always been true in America that some flavor of the frontier spirit has pervaded even the settled communities—some love of freedom, some boldness of action, some primitive sense of fair play. So it is not unreasonable to suggest that the great body of normal, sane, practical, respectable people, the people with whom philosophy is not a vocation, will, especially if they be American and have the blood of frontiersmen in their veins, nevertheless find the essential spirit of philosophy congenial. They will, perhaps, wish to make occasional excursions for themselves; but in any case, they will respect those qualities of mind that prompt other men to plunge into the deep waters and roam the trackless forests of the great intellectual adventure.[8]

By way of summary, we recall that philosophy is a group of problems. It accepts as its own both the problems of the nebulous philosophical sciences and the problems of a comprehensive science. Its comprehensive functions include, first, giving birth, then, settling quarrels, and finally, harmonizing in one house the several somewhat self-centered sciences. And "a mother's work is never done."

What theories are philosophical theories? Perhaps the simplest, if somewhat inaccurate, answer to this question is that philosophical theories are those which have been propounded by philosophers. This leaves the problem of deciding who were and who are philosophers. Such an answer may serve when we are concerned with philosophical theories of the past. Traditions have developed in the history of philosophy. We now point without question to Socrates, Plato, Aristotle, Plotinus, St. Augustine, St. Thomas, Bacon, Hobbes, Descartes, Locke, Berkeley, Hume, Spinoza, Leibnitz, Kant, Hegel, Schopenhauer, Schelling, Neitzsche, Bradley, Bosanquet, Royce and James.

But there are many others. And who shall decide which others? Further, not every theory proposed by each of these men can be considered philosophical—Berkeley's essay on tarwater, for example. Yet such an answer suffices for the novice investigating history, provided he select a competent guide.

But for contemporaries—how shall their status be decided? Dewey, Whitehead, Russell, most will agree, are philosophers. But who else? There are hundreds who deserve the name. Yet not every teacher of philosophy is a philosopher. How shall the line be drawn?

Another answer to our question is this: Solutions to philosophical problems are philosophical theories. Having determined what problems are philosophical, it becomes comparatively easy to determine what theories are philosophical. In epistemology, for example, realism, idealism, pragmatism, mysticism, scepticism and solipsism are properly classed as philosophical theories.

Still another answer has been given. Here attitude and method are deciding factors. Barrett, as previously cited, would reply: "It is not the specific content of these conclusions, but the spirit and method by which they were reached, which entitles them to be described as philosophical."

Philosophical theories are a genuine part of philosophy. Philosophical problems constitute philosophy. Philosophical method is essential to philosophy. And there can be no philosophy without the philosophical attitude. These components are major in a complete description. This is what philosophy is—to-day.

[8] R. B. Perry, "A Defense of Philosophy," pp. 55–6.

THE FIELDS OF ENVIRONMENTALISM

By Dr. RODERICK C. PEATTIE

PROFESSOR OF GEOGRAPHY, OHIO STATE UNIVERSITY

THIS paper is presented because of the distinct condemnation which Pfeifer[1] has uttered against environmentalism. Also Hartshorne[2] recently has chosen to lay emphasis so almost completely upon cultural rather than environmentalistic geographic philosophy. In this reply I shall almost immediately belie myself. After pleading against over-rigid definitions, I shall risk attack by making three limiting descriptions. A tendency towards too-great definition in any field is dangerous. It is a poor omen. Science, like art, is in a decadent stage when it becomes conventionalized. Philosophic progress can be measured by the willingness to explore. The complacent or timid stay at home. In a colony of coral polyps it is the organisms on the fringes of the reef that are best nourished. It is the frontier that gives most to history. Geography is no exception. I must give credit to those who would construct a strong core of what is called pure geography. But more leaven is to be found upon the margins. The stimulation that means progress is for those who explore perilous frontiers. In such advanced areas definitions of fields of study are merely restricting.

Having spoken against definitions, I find it, however, necessary to my thesis to differentiate between chorographers, cultural geographers and environmentalists. I hasten to add that to me these schools of effort are none of them oppositional, but that they are complementary. Moreover, the supporters of each are ordinarily regionalists. My personal reaction to geography is that it is little if not regional. No regional contrasts—no geography. Even comparative geographers must have regional concepts as a basis of their comparisons.

The chorographer is a trained observer. He records minutiae with scientific accuracy. The results of his work are fundamental. Chorographers are trained landscapists, archivists. I count myself as one among them. I value the experience. I believe every geographer should undertake chorographic studies. On the other hand, I am quick to state that chorography has its limitation. It is difficult to conceive of chorography as a philosophy. Such a technique of approach should never be thought of as an end in itself. Collecting facts leads to erudition but not necessarily to intellectuality in the philosophic sense. Robert Platt supports this idea in his recent article on British Guiana. Certainly, the chorographers were correct when they insisted that accurate recording of facts must precede generalization. On the other hand, we do not need to map every square mile of the earth, except by way of inventory. I believe the sampling of typical areas will serve our purpose. I exemplified this in a study of the Eastern Pyrenees. Again, geologists, from whom we borrowed the survey method, do not map every detail of a mountain range before theorizing upon orogeny. Also, limitations of chorography are illustrated by the prevailing unliterary character of the reports. I find them dull reading. I have been guilty of this same boring of my public.

[1] Gottfried Pfeifer, "Regional Geography in the United States Since the War," American Geographical Society.

[2] Richard Hartshorne, *Annals of the Association of American Geographers*, September and December, 1939.

The cultural school of geography in distinction to the environmentalistic school arises naturally from the reciprocal character of the geographic relationship. The philosophy of each school is in no way exclusive of the other. The cultural geographer concerns himself with man's adaptation of the earth to his purpose. Thus a sophisticated landscape is the result of man's choice. Rightly most geographers are cultural geographers because most of the features of modern countries are artificial. Think of a campus, the arrangement and material of the buildings and its exotic Gothic arches. I, personally, have not contributed greatly to this line of thought because I fear that in many cases, dealing as one does with such obvious tangibles, my conclusions would be patent to all. The field lacks, to me, controversial aspects except when it enters the realm of economics. By way of indicating that much excellent work is accomplished by people outside our academy, let me mention that my favorite piece of cultural geography is called "Grape Harvest." It is by Nora Waln and is found in the *Atlantic Monthly* for October, 1937.

I must now defend that Cinderella, environmentalism. Environmentalism has been sent to the corner in the ashes because of the error of her ways. I grant no scholarship has been more erroneous than that of environmentalism. As stimulating as Bodin, Montesquieu and Buckle were in their day, their generalizations were damaging to the philosophy. Even the well written dust-to-dust statement that opens Miss Semple's great book is sentimental rather than rational. Some of the environmentalists have been faulty, to say the least, in their thinking. Reputable journals have printed material that never should have gotton into print.

What is this environmentalism? It is usually thought of as the slow and not easily measurable influence of physical factors on the ways of life. Ordinarily, it is a passive influence whose result is perceptible and best measured in terms of the centuries. It involves such factors as isolation and directional contacts. It results in such conclusions as geographic limitations to cultures or the diffusion of cultures. Contrary to the popular belief it is seldom, indeed almost never, deterministic. Rather, *cultural* geography is the school of thought which leans towards determinism.

Because there is so much insistence that environmentalists are determinists, I must clarify the matter. So far geographic factors have been referred to as passive. Such influences are in the economic aspects of life only limitations. The presence of coal does not determine an industrialism. But let physical conditions alter, and it is another matter. Let aridity increase in Central Asia or the Dust Bowl, and aridity is found to determine a change in the affairs of man. You are all familiar with Ward's sketches of what happens to the farmer's family during the passage of a tornado. All catastrophic geography is deterministic. Ellsworth Huntington's theory of climatic energy in human affairs approaches a definite control. I suspect that the concept of exhausted resources forcing us to a reconsideration of our economies might furnish some with a belief in environmental determinism. I am willing to go further and say that the demands of conservation are forcing upon us a new socialism.

An evaluation of the several factors controlling cultural facts and events may be obtained from conceiving all history as existing within a cube. Let us begin our three dimensions with the lower, forward right-hand corner. The three dimensions shall represent the three factors of heredity, environment and human choice or volition. Proceeding from this corner each dimensional arrow would represent increasing importance of each

of the factors. Every fact of civilization may then be plotted in space within the cube according to the varying importance of the three factors. Most human history has, of course, a genetic predetermination. However unimportant, the environmental factor is certainly present. The human choice is all too obvious. Again, the Gothic arches of the university are a matter of human choice. If there is a determinism due to any one factor, the results must be plotted at the far corners of the cube. Such results are mathematically highly improbable. To believe in a single factor as deterministic, we must demand of our judgment that two of three variables be reduced to zero and, on the percentage basis, the third factor be rated exactly one hundred. Such conditions may happen but obviously are rare. The question of determinism is therefore hardly worthy of our attention. And by determinism I mean a dynamic and not a limiting force.

Is environmentalism of any significant service? The primary field for the environmentalist may be looked upon by the geographer as too broad for his attention. This is the field of environmentalism as opposed to genetics. There are excellent books in this field by biologists and medicos, as the recent "Environment and Growth" by Sanders. The geographer, with few exceptions, has ignored the fine philosophic opportunities to be found there. He is at times sorely needed because the biologists and medical research men are not qualified by training to evaluate geographic factors. As we maintain sub-departments of biology called genetics, we should maintain sub-departments of environmentalism.

A second field is that of the geographical factor in history. Unfortunately the English have perverted the phrase, historical geography, until it stands for merely place geography written into history. But some historians have been lucidly conscious of the geographical factor in history. Lack of support of this important philosophy of history is the geographers' fault rather than the historians'. More has been done along this line in ancient and classical history than in the later periods. I have only to mention the names of James Breasted and Ellen Churchill Semple. I can not think of any brand of geographic thought which has a greater opportunity for philosophic depth or for popular appeal. The economic historian and the realist in current affairs, usually non-geographers, have seized upon the opportunity. But again, the trained geographer is here needed and too seldom has responded.

A third, and my last, field for the environmentalist will, I am afraid, not appeal to many persons and yet is a problem of regionalism. There is interaction between the three factors of my postulated cube. Environment and heredity interact upon each other. Man's choice affects both the other factors. We can not deny then that environment affects man's choice. In short, environment affects psychology. There is a regional psychology. Obviously, the geography of mental characteristics is not of the same definitude as regional economics. But lack of definition makes a fact none the less real. That which can be defined or even proved may be of less significance than the unprovable and imponderable. After all, much cultural history and certainly a great deal of current conflict is based upon regional psychology. That there should be a geography of cultural attitudes is not startling. Philosophers, essayists, novelists, poets and artists have known it for a long time. Geographers, however conscious of it they may have been, have given the influence of physical circumstance on psychology little written support.

If philosophic writers in other disciplines and the creative arts are taking advantage of environmentalism, we

should in turn take advantage of them. Geographers will do well to read the psychologies of MacDougal, Porteus, Kuffka and Lewine. After reading Cressey on China, go to the works of Pearl Buck. Her characterization of Wang Lung and his obsession for land is grand Chinese culture. No one has demonstrated better the harmony between soil, rhythm of nature and peasant mentality than Louis Adamic in "The Native's Return." There remains yet for the geographer to surpass the relationship of depleted resources and mental depression exemplified by Archibald MacLeish in "Land of the Free." I have read one of MacLeish's manuscripts critically, and I know he prepares himself well in environmentalism.

Since we do not believe in actual inheritance of social traits, we must search for other causes for the persistence of national psychologies. The answer is that there is a cultural surge to history. Strong and often dominant factors in culture character are isolation, the soil, the climate, the sea. Indeed, the most sensitive measure of regionalism is a people's temperamental attitude towards life. We have definitely discarded the theory of racial characteristics for the more plausible culture characteristics. Celtic imagination is not inherited, it is handed down. Psychologies are not inbred; they are intrained. And the greatest discipline we receive has always had an earthly origin. Environment is like a number of finely meshed screens, selective according to the shapes of the interstices. We encounter these screens in our restlessness or as the screens change with unstable physical conditions. The story begins with the isolated culture of Egypt. It explains the sea motif in Greek history. It can not be ignored in Soviet affairs.

I am not insisting that we must all as ecologists pursue environmentalistic theories. Thinking environmentalistically means casting aside exact postulations, formulas and conclusions. It calls for imagination and a quality of scholarship which at times may seem not to be starkly rational. Yet, if it lacks statistics by which the equation may be solved, it frequently demonstrates by its logic more significant hypotheses and theories that can be demonstrated by the clearly observable. Moreover, its even partial conclusions are frequently of as wide interest and of as great philosophical consequence to the world as a whole as is the enumeration of sequence occupance.

Yet, I hold in high respect the advanced labors of the chorographer and cultural geographer. The chorographers' work is basic. Only after the cultural geographer has completed his work can the environmentalist reach his complete conclusion. But I must insist that environmentalism remains a significant pursuit of great philosophic depth. It has been so for two millenniums. In all justice, let me say, that if cultural geographers do not wish to recognize environmentalism as having a place above the salt, environmentalism welcomes and needs the efforts of its younger brother. Geneticist, environmentalist, cultural geographer and psychologist should unitedly put their shoulders to the wheel. I might well have labeled this paper, which is little more than an exposition of a personal choice of philosophy, "With Malice towards None."

BOOKS ON SCIENCE FOR LAYMEN

THE TRUTH ABOUT THE CUCKOO[1]

NEARLY two decades ago, Mr. Edgar P. Chance published his first book on the European cuckoo, *Cuculus canorus*, and simultaneously exhibited the motion picture record of his observations, both entitled "The Cuckoo's Secret." It is no exaggeration to say that no single study of any particular species of bird ever caused as much interest and heated controversy as did this one. Chance was able to reveal so convincingly that so much of what had passed for knowledge was in reality only unwarranted assumption or ill-founded tradition that many die-hards, finding themselves unable to adjust their thoughts to the new evidence, clamored loudly against the cause of their discomfort. From the start it was obvious that all the direct positive evidence was on Chance's side, and the years have witnessed a more and more complete acceptance of his conclusions. The main points that Chance established were: (1) the cuckoo lays her eggs directly into the nest of the victim and not, as previously stated, on the ground, subsequently placing them in the nest with her bill; (2) the female cuckoo has a definite territory to which she adheres throughout the season; (3) each female cuckoo lays a constant type of egg and is decidedly specific in her parasitism, *i.e.*, uses only nests of a single kind of bird as a host; (4) by destroying the nests of the favorite host species in sequence, so that only one nest was available at a time, it was possible to force the cuckoo to lay in a given nest and therefore to witness the process. Since Chance's first book in 1922, a number of other observers have used his methods and fully confirmed his observations.

In his new book, here under review, Chance repeats all that was said in his earlier one and gives many additional data from subsequent observation of the same individual cuckoos and of other ones as well. In addition, he discusses such topics as accidental fosterers (species rarely parasitized), the adherence to fosterers (host-specificity), the behavior of fosterers when subject to a cuckoo's attention; the young cuckoo and, especially, its habit of ejecting other young or eggs from the nest, and the question of mating and pairing and the moot subject of territory and territorial dominance in the cuckoo. He produces a considerable body of evidence suggesting that the cuckoo may pair as do most birds and not be guilty of the promiscuous excesses literature has attributed to it. Chance even hints that pairing may be for life—but for this there are no proofs.

The final topic discussed is the matter of the variation in cuckoos' eggs and the evolution of adaptive similarity in the egg of the parasite to that of its favorite host. As Chance says, ". . . If one examines an extensive range of cuckoos' eggs, together with those of the fosterers with which they have been found, one can not help observing how often the eggs of the parasite tend to resemble those of the fosterers. . . . To put this another way, let us picture say three hundred cuckoos' eggs mixed up at random which have been genuinely taken as to one hundred each from nests of pied wagtail, meadow pipit and reed warbler. I am suggesting that the experienced oologist would, with more accuracy than error, sort out these eggs and assign them to their correct foster species. Surely this shows that evolution in coloration has been and is going on? . . . Of course, if it is argued that similarity can occur infinitely often by coincidence, then the whole case for 'adaptation' or 'evolution' in cuckoos' eggs falls to the

[1] *The Truth about the Cuckoo.* Edgar Chance. xvi + 207 pp. 1940. Scribner's Sons.

ground, but I share the view that the percentage of cases of striking resemblance between cuckoos' eggs and those of their fosterers is too great to be mere coincidence." This leads to the contention that the species, *Cuculus canorus*, is composed of gentes, each gens normally parasitizing a particular species of fosterer (the number of common hosts being not very large, the number of gentes would be equally moderate, all cases of rare victims being considered as accidental in one way or another) and that matings take place within the same gens. The genetics of the cuckoo are, of course, very imperfectly understood, but in an appendix to Chance's book, Professor R. C. Punnett has added a most interesting and suggestive chapter on the genetical aspect of the cuckoo. The value of this chapter will become apparent in the work it may stimulate on this fascinating subject.

The reviewer has a special and very deep interest in the problems touched upon in this book, because it so closely parallels his own work on the cowbirds. He is continually impressed by the close agreement he finds in interpretations and results between his own experience and Edgar Chance's, especially when taking into account the very different birds each has worked with. If Chance's work needed any indirect corroboration and support, the data on the cowbirds would give it.

HERBERT FRIEDMANN

MAMMALS OF AMERICA[1]

A CAREFUL reading of this book will convince the reader that the author has made good use of original literature sources, that he is thoroughly conversant with the subject-matter and that he has carefully considered the presentation of pertinent facts. It is a book that every mammalogist, naturalist and sportsman will want to read. Representative types of the mammal families of North America, from Panama to the Arctic barren lands, are chosen to illustrate the particular topic under discussion, but no attempt is made to give detailed accounts of each species. The first two chapters are devoted to a discussion of the ancestry and classification of mammals.

Prior to the publication of "American Mammals," reference works available to the interested reader were mainly state descriptive lists, taxonomic treatises of genera, economic reports and game management accounts. From all these and many other sources data were drawn in preparing the chapters on adaptations, food, storage, reproduction and early life, homes, hibernation, migration, populations, behavior and distribution. The concluding chapters are arranged in such a way as to give a general account of the economic relations of mammals. Those in this category are classed as useful mammals, injurious mammals, game, fur-bearing and predatory mammals.

In the chapter on the characters of mammals, the reader gets a good insight into the function and use of teeth, hair specialization, pelage coloration, antler and horn structure, body temperature, normal actions of skin glands and secondary sexual characters. Especially instructive to the lay reader is the chapter dealing with the external and internal modifications of mammals for swimming, burrowing and climbing, and the factors that make existence possible in polar regions and in desert areas. Since Rubner's body surface law is the premise around which much of the section on Arctic mammals is organized, attention should be directed to the somewhat different conclusions reached by Benedict (1936, Carnegie Inst. Washington Publ. 474, pp. 282–286). In all the chapters the emphasis lies distinctly on the ecological approach as a means for interpreting the various phases of mammalian biology. One of the best features of this

[1] *American Mammals.* W. J. Hamilton, Jr. Illustrated. xii + 434 pp. 1939. $3.75. McGraw-Hill.

book is the direct citation of consulted source materials.

REMINGTON KELLOGG

THE PATIENT'S RESPONSIBILITY [1]

OPTIMISM is a potent force, but it is not omnipotent. Carried to extreme it is prone to become self-destructive. Science must be constantly conscious of the dangers of wishful thinking. We must not promise more than we know is feasible. The promise implied in the title[1] of a recent book for the lay reader on problems of health preservation is misleading. Health and longevity are not to be had for the mere asking; fairies and genii no longer work miracles upon request. Neither can the physician maintain health without earnest effort on the part of the patient. And even then, there are many to whom health and life are denied. To be sure, modern medical science now has far more than ever before to offer the person seeking sound advice as to how to maintain health and prolong his years. The *potentialities* of personal preventive medicine are immense, but their realization depends largely upon the conscientiousness of the individual patient.

Mankind reveals a curious perversity in declining to exert himself in prophylaxis on his own behalf. The causation of several of the significant and increasingly menacing disorders of middle and later life is frequently associated with indulgence and excesses. Thus, preventive management often involves irksome restrictions and prolonged personal efforts. All too often the dislike for such continuous limitations leads to their neglect; the physician is then blamed for the failure of the régime. Few, indeed, are those individuals who do not welcome an opportunity to pass responsibility to another. It is, therefore, doubly dangerous to imply that mere asking for health suffices. Pampering paternalism has already wrought havoc with the sense of responsibility of our citizens.

Throughout the book Dr. Steinerohn maintains a strongly optimistic tone. Such encouragement is desirable and should bring many well people to their physicians. This is the first and vital step in personal health maintenance.

This message can not be over-emphasized. But there is just a little too much stress upon what the doctor does and too little clarification of the patient's own responsibility to himself. Ambrose Paré, the father of French surgery in the sixteenth century, was fond of saying, "I dressed his wounds and God healed him." To-day's version of the relative rôle played by the physician might read: "The doctor assists the body to do its own repairing." For example, we may prescribe medication for the correction of an anemia, but it is the body which must manufacture the blood cells.

Information for the layman on health evaluation, heart disease, cancer, diabetes, pneumonia and similar problems is clearly presented. The statements are sound. Very little effort is made, however, in explaining the mechanisms underlying disease and the basic reasons for therapeutic procedures. It has been the reviewer's experience that intelligent and effective cooperation is obtained best when the patient understands *why* he or she should do things. The style is light, with many personal narrative sketches used to illustrate the author's points.

In contrast with the many widely inaccurate books of health, hygiene and medicine intended for the layman, this is a very sound contribution and fits well in the "Popular Health Series" of the publishers. It is not, however, an outstanding or profoundly significant volume.

EDWARD J. STIEGLITZ

[1] *More Years for the Asking.* Peter J. Steinerohn. 218 pp. $2.00. 1940. D. Appleton-Century Company, Inc.

AERIAL VIEW OF THE CAMPUS OF THE UNIVERSITY OF NEW HAMPSHIRE

MEETING PLACE OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE IN JUNE. IN LEFT FOREGROUND IS A GROUP OF DORMITORIES, CONSISTING OF HETZEL HALL, FAIRCHILD HALL AND THE COMMONS. BEYOND THEM IS THE HAMILTON SMITH LIBRARY AND BEYOND IT, NEAR THE FLAG-POLE, IS THOMPSON HALL, THE ADMINISTRATION BUILDING. IN THE DISTANCE, AT THE BEND IN THE STREET, IS THE FIELD HOUSE, WHICH, WITH SEATING CAPACITY OF 3,500, MAY BE USED FOR MEETINGS.

THE PROGRESS OF SCIENCE

SCIENCE AND VACATION AT DURHAM, N. H.

FROM June 23 to June 28 the American Association for the Advancement of Science will combine business with pleasure in holding a meeting at Durham, New Hampshire, in connection with the celebration of the seventy-fifth anniversary of the founding of the State University. Immediately preceding the meeting of the association the university will hold a Congress of Science and Humanities as a part of the celebration.

The meeting of the association will be a pleasure to those who participate in it because on its thirty-five programs there will be many reports of new adventures in science. It will be a pleasure to pass a few days in the tranquil atmosphere of a university town. It will be a pleasure to draw apart briefly from the strife of the day and take a long look at the nature of the physical and biological worlds and at the problems of man. It will be a pleasure to visit the sea, the lakes and the mountains of perhaps the most restful and delightful vacation land in our country.

Although the association will hold a meeting from September 22 to September 27 at the University of Chicago in connection with the fiftieth anniversary of its founding, a varied and interesting program will be presented at the Durham meeting. It will range from the rare atmosphere of abstract mathematics to the racial origins of the inhabitants of present New England. The meteorologists will consider questions pertaining to the atmosphere above and the geologists to problems of the earth beneath our feet. The programs of the botanists and the geologists will consist largely of field trips. Somewhat envious members of other sections and societies may attempt to tease their botanical and geological friends about calling pleasure trips science, but the latter can make the rejoinder that Pope would have said, if he had written on the subject, that the proper study of botany is plants and of geology is the earth, and few would have challenged the statement.

Other sections and societies will visit laboratories of various kinds, experiment stations, gardens, forests, etc. The Section on Social and Economic Sciences will devote three days to discussing social and economic problems of New England. Questions of the production of food will be considered in the programs of the horticulturists and agronomists, the preservation and use of forests by the foresters, and the protection of human health by the Section on the Medical Sciences. Long ago Dr. L. O. Howard, then permanent secretary of the association, said that the greatest war on the earth is that between human beings and insects. That this has become an all-out war in dead earnest is proved by a symposium in which the entomologists will present coldly explicit directions for killing insect enemies—the young and old, both while resting in their homes and while at their regular business—by the use of the most deadly poisons the chemists can produce.

As states go, New Hampshire is not great in area or population, but it has a long and honorable history and its people have always been noted for their granite integrity. What is now New Hampshire was first seen by white men when Martin Prang visited its coast in 1603. Two years later Champlain discovered the Isles of Shoals off its coast. Captain John Smith visited it in 1614 and wrote enthusiastically of its attractions. John Mason, who received a land grant from King James I, in 1622, is known as the founder of New Hampshire. The first indisputable settlement in New Hampshire was by David Thompson, in 1623, at Little Harbor (now Rye). Originally a part of Massachusetts, New Hampshire did not become a separate province until 1679.

At the outbreak of the American Revolution New Hampshire had about 80,000

inhabitants, most of whom ardently desired to become separate from Great Britain. In fact, on June 15, 1776, two weeks before the Declaration of Independence, its Assembly voted for separation from the mother country. It was, however, the ninth state to ratify the Federal Constitution; the vote of its Assembly in 1788 gave the two-thirds of the thirteen original states necessary to make the Constitution effective.

New Hampshire was a part of Massachusetts when, in 1647, it passed a law requiring every town having fifty householders to maintain a school for teaching reading and writing, and every town having one hundred householders or more to maintain a grammar school. It has preserved to an exceptional degree the fine qualities of the neighborhood school, and one might still often say with Whittier,

> Still sits the school house by the road,
> A ragged beggar sunning,
> And round it still the sumacs grow
> And blackberry vines are running.

The little red school house on the hill lacked the lavish equipment and the athletic teams of modern public schools, but it opened somewhat the windows to life and lore and instilled deeply the fundamentals of human character. No one can certainly say at present which type of education in the long run will be the better.

New Hampshire, however, has kept in tune with the progress of higher education. Dartmouth College first opened its doors in 1769 and for more than 170 years has occupied an honorable, and in some respects an almost unique, place in college education. In 1856, Benjamin Thompson, a farmer of Durham, left his entire estate to the people of New Hampshire to establish a college of agriculture on the land he had owned. The University of New Hampshire, beginning in 1866 as a department of Dartmouth College, was removed to Durham in 1891. It now consists of the College of Agriculture, the College of Liberal Arts, the

HAMPTON BEACH, ONE OF THE MANY RESORTS NEAR DURHAM

SCENIC ATTRACTIONS NEAR DURHAM VARY FROM BEACHES, SUCH AS THIS 20 MILES DISTANT, TO THE WHITE MOUNTAINS AND LAKE WINNEPESAUKEE, WHICH ARE ONLY A FEW HOURS' DRIVE AWAY.

GREAT BAY FROM WEEK'S POINT, IN DURHAM TOWNSHIP
THIS INLET ON OYSTER RIVER, AT THE HEAD OF THE TIDEWATER, IS ABOUT THREE MILES FROM THE CAMPUS OF THE UNIVERSITY.

College of Technology, with their numerous departments, and its Graduate School. It has a faculty of nearly 200 of the grade of instructor and higher and more than 2,000 regularly enrolled students. In its summer school this year, beginning on June 30 and closing on August 8, courses will be given in more than 60 subjects, including all those usually found in college courses. In addition there will be held the fourth annual Institute of Public Affairs, a Writers' Conference, a Guidance Institute, an Elementary Education Conference, a Library Institute and an Office Workers' Institute.

Durham is in a region rich with memories of great leaders in learning and literature of an earlier day. In this area Whittier, Hawthorne, Longfellow, Emerson, Thoreau, Webster, Thaxter and Aldrich lived and worked, and there are found shrines in their honor. The university is only a few miles from ocean beaches and within a half day's drive of hundreds of beautiful lakes of the central part of the state. Lake Winnepesaukee, twenty miles long and from one to eight miles wide, is noted for its 274 green islands. To the north are the mountains culminating in Mount Washington in the Presidential Range with an altitude of 6,293 feet. Following the scientific meeting at Durham from June 23 to June 28, many of the scientists and their families will journey northward for pleasure to the lakes and the mountains, to silence and to solitude—no! not to solitude, for as Byron has written,

> To sit on rocks, to muse o'er flood and fell,
> To slowly trace the forest's shady scene,
> Where things that own not man's dominion dwell,
> And mortal foot hath ne'er or rarely been;
> To climb the trackless mountain all unseen
> With the wild flock that never needs a fold;
> Alone o'er steeps and falls to lean;
> This is not solitude; 'tis but to hold
> Converse with Nature's charms and view her stores unrolled.

F. R. MOULTON

THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

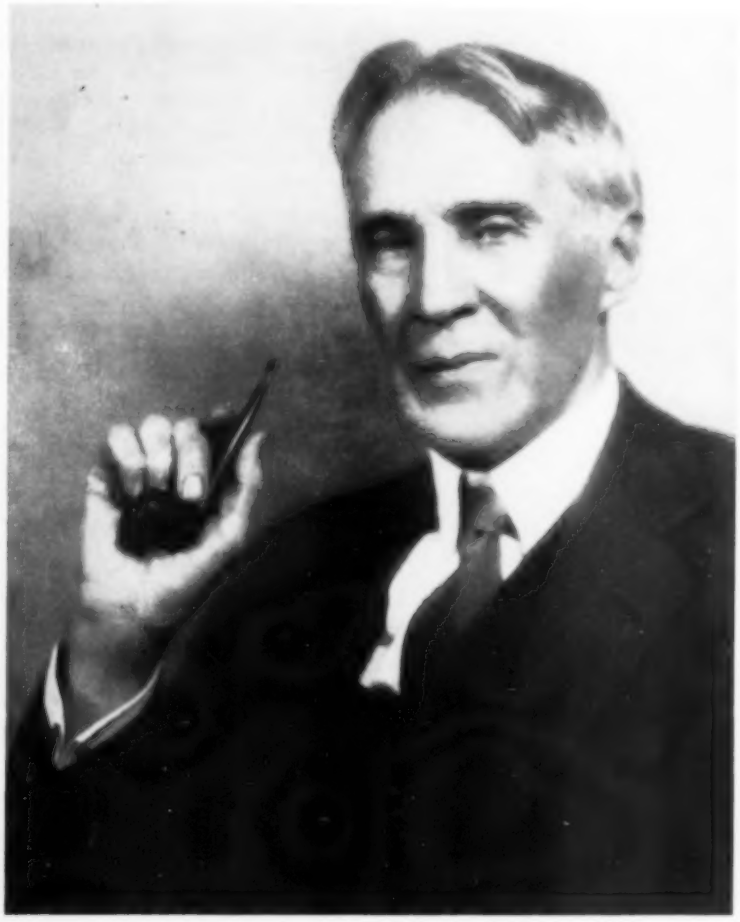
THE seventy-eighth annual meeting of the National Academy of Sciences was held on April 28, 29 and 30, 1941, at the Academy building on Constitution Avenue, Washington, D. C. One hundred and thirty-three members and one foreign associate attended the meeting. At the scientific sessions thirty-two papers and two biographical memoirs were presented; of these, twenty-one papers were given by members. The distribution of the papers among the sciences was: mathematics, 1; astronomy, 3; physics, 5; chemistry, 2; geology, 5; botany, 5; zoology, 6; physiology, 1; biochemistry, 1; anthropology, 1; psychology, 2; oceanography, 1. In presenting his paper each speaker sought to emphasize the general nature of his investigation and to limit technical details to essential data, so that the purport of the work might be more readily understood by scientists outside his special field of research. As a result the papers were unusually interesting and were freely discussed. The average attendance at the scientific sessions was 300.

On Monday evening the public lecture was given by Drs. R. A. Millikan, H. Victor Neher and W. H. Pickering, of the California Institute of Technology, on "Testing in India a theory of the origin of cosmic rays" to an appreciative audience of 350. The lecture was followed by the showing of still and motion colored pictures taken by Dr. Neher in India and on the journey to and from India.

At the annual dinner the president of the Academy, Dr. Frank B. Jewett, discussed briefly the many problems faced by the Academy in connection with requests by the Government for advice and noted the progress that has been made in solving a number of these problems. He referred also to the steps that have been taken to establish the proposed National Science Fund. A committee of the Academy under the chairmanship of Dr. A. F. Blakeslee has been working

DR. T. Y. THOMAS
PROFESSOR OF MATHEMATICS, UNIVERSITY OF CALIFORNIA, LOS ANGELES.

DR. ARTHUR S. KING
SUPERINTENDENT OF THE PHYSICAL LABORATORY, MOUNT WILSON OBSERVATORY, PASADENA.



DR. ROBERT WILLIAMS WOOD

RESEARCH PROFESSOR OF EXPERIMENTAL PHYSICS AT THE JOHNS HOPKINS UNIVERSITY, WHO WAS AWARDED THE HENRY DRAPER MEDAL.

on this proposal for several years; at the business meeting of the Academy the committee submitted a proposed constitution for the Fund together with recommendations for its administration. The constitution was adopted by the Academy. The object of the National Science Fund, as stated in its constitution, "shall be the promotion of human welfare through the advancement of science." Under the sponsorship of the National Academy of Sciences, the National Science Fund may receive bequests, donations, grants and other gifts to be administered by a Board of Directors appointed by the Council of the Academy. The Academy is the official scientific adviser to the Government and is qualified to evaluate the needs of science and to assure wise use of funds provided for research in science. To administer the National Science Fund the Council of the Academy appointed a Board of Directors consisting of 12 non-Academy members, and 17 Academy members; in addition, the President and Treasurer of the Academy, the Chairman of the National Research Council, and the President of the American Association for the Advancement of Science serve as *ex officio* members.

Organized as an agency of the Na-

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tional Academy of Sciences, the National Science Fund is a permanent mechanism which affords donors, who may desire to devote funds to the welfare of mankind through research in science, assurance that wise administration will safeguard the entrusted funds and disburse them in support of effective original work in science.

The Henry Draper Medal was awarded to Robert Williams Wood, research professor in experimental physics at the Johns Hopkins University, in recogni-

DR. W. E. BACHMANN
PROFESSOR OF ORGANIC CHEMISTRY, UNIVERSITY OF MICHIGAN.

tion of his contributions to astronomical physics; more especially his pioneer work upon resonance spectra, his use of color filters in astronomical photography and his development of methods for concentrating to a high degree the light from diffraction gratings in desired orders and regions of the spectrum. Such gratings not only are of great value in solar and laboratory spectroscopy, but have made possible the use of higher dispersion than has hitherto been employed in

the study of stellar spectra and the extension of observations into the far ultraviolet. Dr. Wood's experiments with objective grating replicas have also led to results of great promise in the photography of spectra of faint stars. In his presentation speech Dr. Otto Struve of Yerkes Observatory emphasized the remarkable advances which Dr. Wood has made in the ruling of diffraction gratings. Through selection and shaping of the point of his ruling diamond Dr.

DR. JOSEPH SLEPIAN
RESEARCH ENGINEER, WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

Wood has succeeded in throwing as much as one half of the incident light into a chosen order of the spectrum. He was the first to achieve excellent results in ruling gratings on films of aluminum evaporated on glass. As a result a Wood grating with high concentration of light is one of the most effective instruments of research in stellar spectroscopy. It has made possible the analysis of the spectra of the brighter stars on a large scale, has opened up the almost unex-

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PROFESSOR OF SURGERY, SCHOOL OF MEDICINE, WASHINGTON UNIVERSITY, ST. LOUIS.

DR. GEORGE GAYLORD SIMPSON
VERTEBRATE PALEONTOLOGIST, AMERICAN MUSEUM OF NATURAL HISTORY.

plored ultraviolet region of stellar spectra, and has already led to discoveries of interest regarding the constitution of the gases in interstellar space.

On Monday afternoon 75 Academy members and guests visited the National Gallery of Art which was erected through the generosity of the late Andrew W. Mellon and was opened to the public only a few weeks ago. Special guides showed the visitors through the gallery and commented upon the various collections of paintings and works of art which were well exhibited and were greatly admired. The architectural effects and beauty of the building itself attracted attention and impressed the group profoundly. The short visit was extremely interesting and was appreciated by the visitors.

At its business meeting on Wednesday, April 30, the Academy elected the following officers and members:

Vice-President

Dr. Isaiah Bowman, president of the Johns Hopkins University, Baltimore, Md.

New Members of the Council of the Academy

S. A. Mitchell, Leander McCormick Observatory, University of Virginia, Charlottesville, Va.

E. B. Fred, professor of bacteriology, University of Wisconsin, Madison, Wis.

New Foreign Associates

Edgar Douglas Adrian, professor of physiology and fellow of Trinity College, Cambridge University, Cambridge, England.

Archibald Vivian Hill, Foulerton research professor and secretary of the Royal Society, London, England.

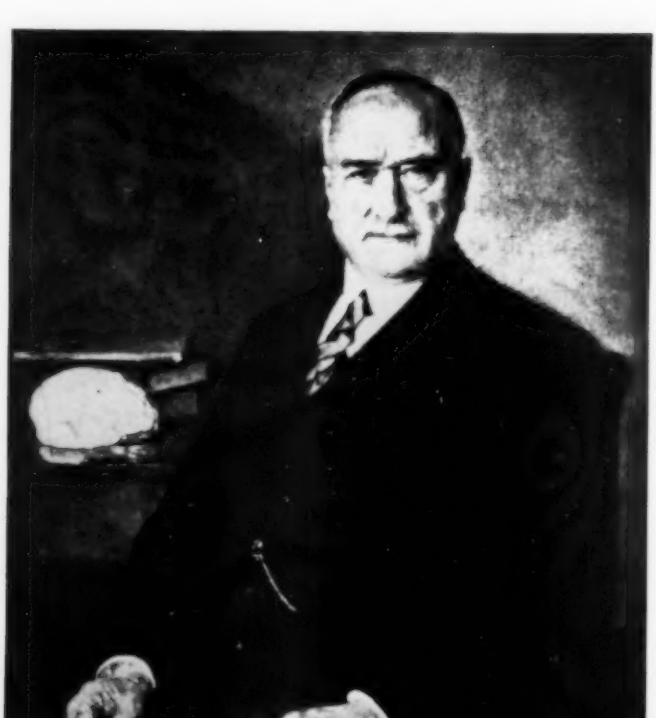
Sir Arthur Keith, Buckston Browne Farm, Downe, Kent, England.

Fifteen men, whose portraits are here reproduced with the exception of Dr. Alfred L. Loomis of the Loomis Laboratories, Tuxedo Park, N. J., were elected to membership in the Academy.

The present membership of the Academy is 319 with a membership limit of 350. There are 5 members emeriti. The number of foreign associates is 42 with a limit of 50.

The autumn meeting of the Academy will be held this year on October 13, 14 and 15 at the University of Wisconsin, Madison, Wisconsin.

F. E. WRIGHT,
Home Secretary



DR. EUGENE DUBOIS, 1858–1940

It has been learned that Dr. Eugene Dubois, famous for his discovery, in 1891, of the skullcap of the Java ape-man, known as *Pithecanthropus erectus*, recently died at his home in Holland at the age of 82 years.

No finds relating to human pre-history have received more attention and publicity than those attributed to the Pithecanthropus, and none deserved more. Nor are the discussions yet ended. The remains were discovered between 1890 and 1897 in Java, by or under the direction of Eugene Dubois.

As a young physician Dr. Dubois was appointed to the service in Java as a result of his own efforts. He was already an accomplished anatomist, paleontologist and student of human ancestry, and he went with the object of searching for possible human ancestors in the East Indies. From 1887 he served as a "Health-Officer" in the military organization of the Colonies, but a considerable part of his time was devoted to a search of the caves in Sumatra and the collection of fossils.

In 1889 Dubois came to Java, and in April of that year he was delegated by the Colonial government, at his own desire, "to extend his studies to the tertiary and diluvial fauna of Java." From then on until the middle of 1895, the government Mining Bulletin carried quarterly a report by Dubois or others on the progress of his work, and it is in these reports that the original accounts of his fortunate discoveries are recorded.

The first note of importance is found in the report for the first quarter of 1890.

Dr. Dubois announces that he had discovered, on November 24, 1890, in the so-called Kendeng deposits of the watershed of the Bengawan river, a human fossil, consisting of a fragment of a lower jaw.

The first report by Dubois on the finds relating more directly to the Pithecanthropus appears in the third quarter of 1891. Speaking of the work near Trinil he says: "The most remarkable find however was a molar tooth (the upper third permanent molar of the right side) of a chimpanzee."

In his report for the fourth quarter of 1891, Dubois announces the discovery of the skullcap, gives the first notes and measurements on it, and attempts its classification. He says: "The Pleistocene fauna of Java, which in September of this year was augmented by a molar of a chimpanzee, was much further enriched a month later. Close to the spot in the left bank of the river where the molar appeared, there was unearthed a fine skullcap which, with even less doubt than the molar, may be attributed to the genus *Anthropopithecus troglodytes*. That both the specimens come from a great manlike ape, is at once clear."

The next note of much interest by Dubois is found in his report for the third quarter of 1892. He here announces the discovery of the femur, and gives the form represented by the finds its first specific name. The femur was discovered, he states, at the same level as the skullcap and the tooth, but 15 meters (nearly 50 ft.) further upstream; and it is plain to him that the three specimens, the tooth, skullcap and femur, belong to the same individual, probably a female of advanced age. "Through each of the three recovered skeletal parts, and especially by the thighbone, the *Anthropopithecus erectus* Eug. Dubois approaches man more closely than does any other anthropoid."

With the season of 1893 the excavations at Trinil came to an end; and towards the end of the second quarter of 1895, Dubois himself departed for Europe.

In 1894 Dubois' first important report on the Trinil remains appears under the title "*Pithecanthropus erectus*, eine menschenähnliche Uebergangsform aus Java." In this he characterizes the new form as follows: Order: Primates. New family: Pithecanthropidae.

In the same original, able and painstaking memoir, Dr. Dubois gives his principal measurements of the skull and corresponding measurements of four chimpanzees and two gibbons.

All the above showed conclusively to Dubois that the form could not be ascribed to the *Simiidae*; at the same time, numerous characteristics of the skull, those of the teeth, and some features even of the femur, indicate that the form cannot be classed with those of the *Hominidae*. It is an intermediary form which necessitates its classification as a new genus, the *Pithecanthropus*, and a new family, the *Pithecanthropidae*. *Pithecanthropus erectus* is a transitional form which must have existed between man and the anthropoids; "it is the precursor of man."

Dubois' reports on the Java finds, and above all the specimens themselves after he brought them to Holland, attracted naturally the liveliest attention of the scientific world. A number of prominent anthropologists, paleontologists, and anatomists, such as Manouvrier, Marsh, Flower, Virchow, Smith Woodward, Sir William Turner, Schwalbe and others, were given the privilege of seeing the specimens; and on September 15–21, 1895, the originals were exhibited to all before the Third International Zoological Congress at Leyden, where they received great attention and much discussion.

Dubois' discovery was universally acknowledged as one of great importance; but his views were soon combatted. The case presented two main problems. The first was the question of whether the several parts, *i.e.*, the skull,

the two teeth and the femur, belonged to the same individual or at least to the same form; the other, that of the identification of this form.

But all this is not the pivotal essential of the find, and diminishes in no wise its high interest and value, both of which are universally acknowledged, particularly since the endocranial cast has become available. Neither should the student allow himself to be confused by the seeming flood of discrepancies of opinion on the remains. The differences are often more apparent than real, and even where real they by no means discredit the find, but are only so many attempts, under all the great limitations of our present collections and knowledge, to reach a true conclusion.

The Trinil skull alone is sufficient to establish the presence in what is now Java, somewhere during the early Quaternary, and possibly earlier, of a class of beings that so resembled the anthropoid apes, on one hand, and came so far in the direction of man in the other, that if they were to be named today we could hardly find a more appropriate name for them than "Pithecanthropus."

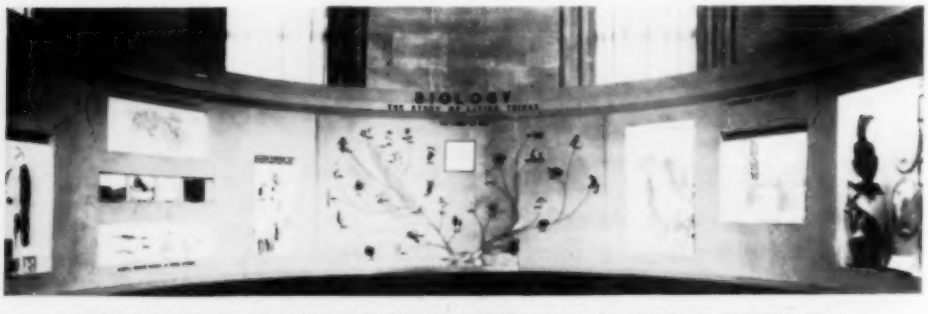
In recent years a number of additional specimens that may be attributed to the Pithecanthropus were found in the same region of Java. These are not yet fully described, but do not change the main conclusions of Dubois.

ALEŠ HRDLIČKA
U. S. NATIONAL MUSEUM

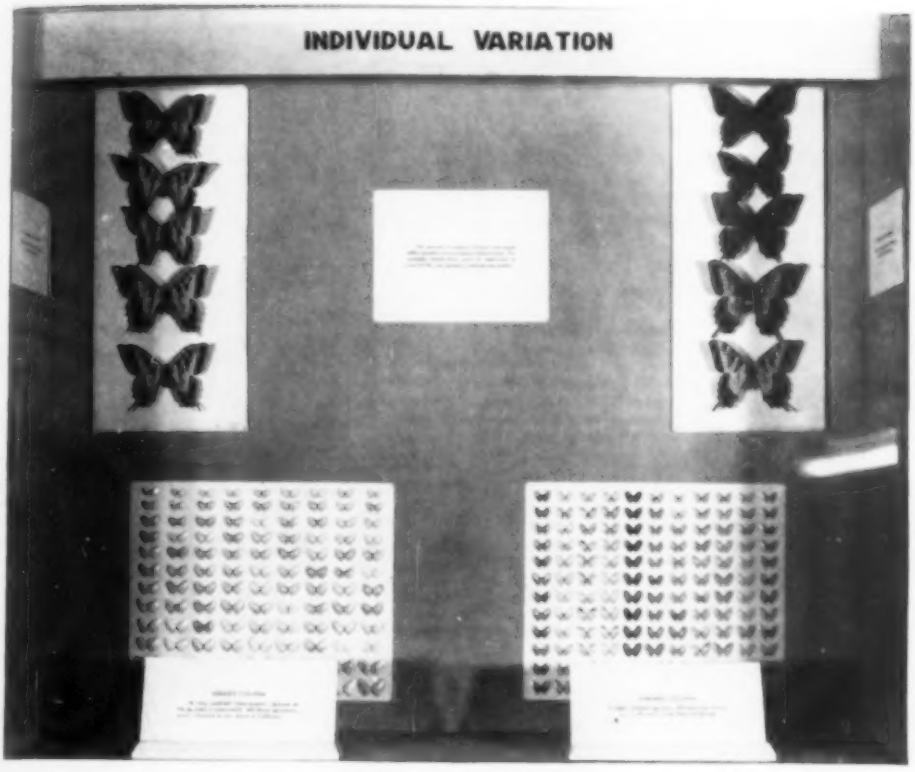
THE BIOLOGY ALCOVE OF THE SMITHSONIAN'S NEW "INDEX EXHIBIT"

THE whole field of the biological sciences is too vast for any one institution to cover. Like other research organizations, the Smithsonian has had to restrict its own labors to a small section of it and has remained faithful to the old descriptive aspects of biology, where it has been one of the most productive institutions in the classical fields of taxonomy and biogeography, leaving to newer laboratories, unencumbered with the care and responsibility of great museum collections, the more recent experimental approaches to the science. The biology alcove in the Smithsonian's new "Index Exhibit" accordingly has for its central theme "the forms of life." Here, on a hypothetical diagrammatic "tree," are painted the main groups of animal and plant life, arranged to show their supposed relationships.

Flanking this are exhibits illustrating the work involved in "description and classification" on the one side and "variation and distribution" on the other. In the former, the theme is developed



THE BIOLOGY ALCOVE IN THE SMITHSONIAN "INDEX EXHIBIT"
THE CENTER CHART IS A DIAGRAM OF THE FORMS OF LIFE. THE LEFT PANEL DEMONSTRATES CLASSIFICATION AND DESCRIPTION, THE RIGHT ONE PRESENTS VARIATION AND DISTRIBUTION.



INDIVIDUAL VARIATION

AN EXHIBIT TO SHOW SPECIFIC PHASES OF BIOLOGICAL WORK. VARIATIONS IN THE SAME SPECIES ARE EXEMPLIFIED IN THIS CASE BY SPECIMENS OF BUTTERFLIES AND SHELLS.

around the basic work, the first main step, that of collecting the materials for the specialists to study. In the upper center is a map of the world, showing all the places where Smithsonian biologists have explored and collected in the past ten years. This map is enlivened by a series of colored transparencies showing field parties at work in various parts of the world. Under this is a recessed case of "recently received material of special interest," containing at present a series of Siamese fresh water fishes, showing remarkable adaptive features and habits. On either side of the expedition map is a vertical recessed case—one with the title, "Collecting Expeditions Add New Species to Knowledge," and the other, "Collecting Expeditions Add New Facts About Known Species." In the former are shown a few selected specimens of new species discovered as a result of Smithsonian work, the total number of which is estimated to be over one hundred thousand. In the other case are illustrated groups of animals and plants being monographed at the present time.

The exhibits dealing with "variation and distribution" comprise three recessed cases. The central one is devoted to the matter of the great range of individual variation in nature—some species being very variable and others quite constant. The examples used at present are mollusks and butterflies. The case to the left of this one demonstrates geograph-

ical variation and the phenomenon of geographical subspecific groups—the song sparrow being used as the illustration. The right-hand case explains biogeography and shows on two colored hemispheres the main biological regions of the world and illustrates by means of specimens the peculiarities of one of these faunal areas, in this case, the Australian region.

HERBERT FRIEDMANN
SMITHSONIAN INSTITUTION

PHYSICISTS IN NATIONAL DEFENSE

IN his report to the Governing Board of the American Institute of Physics, Dr. Henry Barton estimated that one out of every four physicists in the United States is working on problems of national defense. The estimated number is 1,400 out of a total 4,100 physicists who are members of at least one national professional society in physics.

A recent survey of more than 130 universities indicates that, of their total staff of 1,100 professors and instructors of physics, over 100 have recently been called away from their campuses for official defense research projects. At least another 200 have been named consultants or assigned full- or part-time defense tasks at their home institutions. Some 50 graduate students of physics have dropped their studies to accept defense assignments.

In addition, there is approximately 300 physicists in the technical services of the army, navy, air corps and other government departments, mostly full time, and of these at least 250 are at work on problems intimately concerned with national defense. It is estimated that 800 of the 2,500 trained physicists employed in industry are at work on problems related to national defense, and the demands of defense agencies and industries for physicists is greater than can be met.

In industry it is estimated that 2,500 trained physicists are employed, many of them in the research laboratories of large corporations. On the basis of reports received at the institute office, at least 800 of these have gone onto new work programs in line with the needs of national defense. Indeed, if all work designed to improve or speed the production of defense materials and products be counted, the number is greater than 800.

Not only is the supply of physicists being strained, but the output of new physicists is being curtailed. The men who have been called from universities for defense research are often those best fitted to train new research physicists. However, their remaining colleagues are assuming increased teaching loads, to keep up the standards of training offered to students.

Unfortunately, the careers of many students are about to be disrupted by the draft. Most of them are unmarried and of draft age. Unless something can be done to keep these much needed students in the graduate schools, the number of men receiving advanced training in physics will drop to less than half of the recent average of 130 per year. What the country needs is to multiply this figure rather than to cut it. Since a thorough training in physics requires three or four years of graduate study, it is nearly impossible to increase the annual increment of good new physicists. Therefore, every effort should be made at least to keep it up.

W. H.

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The Separation of Gases. M. RUHEMAN. Illustrated. xiii + 283 pp. $5.75. March, 1941. Oxford.

The object of this book is to supply an account of the technique and theory of gas separation which will appeal to both the gas-separation engineer and to the physicist and chemist of wide general interests.

Silver in Industry. Ed. by L. ADDICKS with 28 collaborators. Illustrated. 656 pp. $10.00. Reinhold.

This volume contains the results of extensive investigations carried out by the government sponsored SILVER RESEARCH PROJECTS with the active cooperation of the National Bureau of Standards, the purpose of which was to stimulate interest in the industrial possibilities of silver.

Catholicism and the Progress of Science. W. M. AGAR. xi + 109 pp. $1.00. 1941. Macmillan.

This is a survey of the historical development of science and its relationship to Christian thought. Particular attention is given to the controversies on geography and astronomy. Evidences of evolution are studied and recent trends in the biological sciences investigated.

Kabloona. G. DE PONCINS. Illustrated. xii + 339 pp. $3.00. 1941. Reynal & Hitchcock.

This book was shaped out of the diaries of the author on life as he witnessed it, north of the Arctic Circle, where the Eskimos still live primitively, both physically and mentally untouched by our civilization.

Rheumatic Fever. MAY G. WILSON. Illustrated. xiv + 595 pp. $4.50. 1940. Commonwealth.

This volume presents the results of more than twenty years' study in the etiology, epidemiology, manifestations, course, diagnosis, prognosis and treatment of rheumatism in persons less than thirty years of age. Extensive bibliographies are given.

Geophysical Exploration. C. A. HEILAND. xiii + 1013 pp. $10.00. 1940. Prentice-Hall.

This is a manual of research in geophysics. The introduction summarizes present knowledge in the subject, but the major part of the book is devoted to detailed descriptions of apparatus to study magnetism, gravitation, mining and seismology.

Psychiatric Social Work. L. M. FRENCH. xvi + 344 pp. $2.25. 1940. Commonwealth.

A study, sponsored by the American Association of Psychiatric Social Workers, concerning the origin, development and future of social work relating to psychiatric cases. Training and new concepts in this field are particularly considered.

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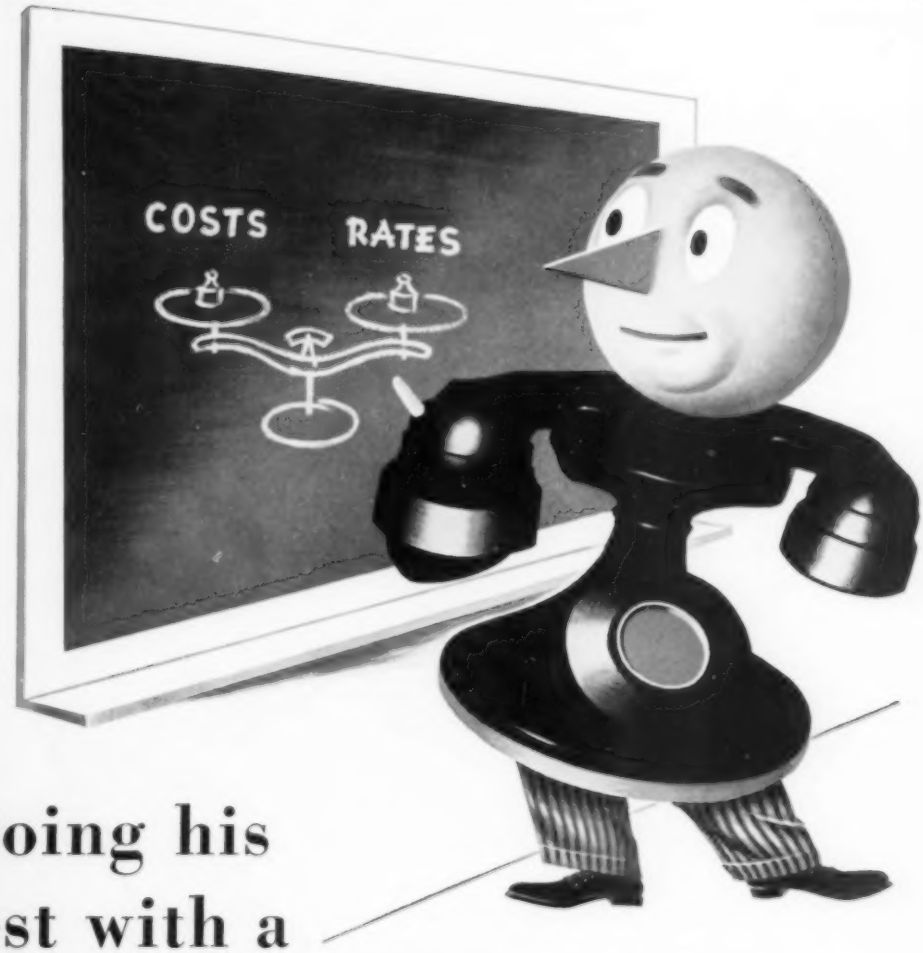

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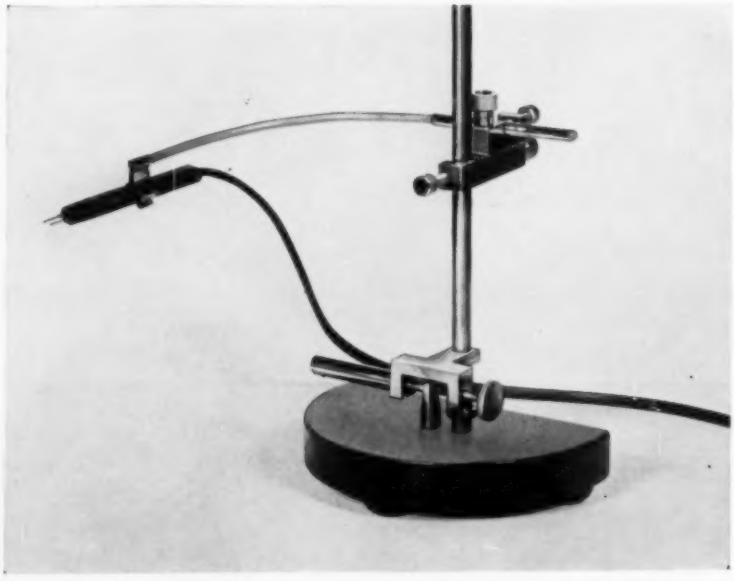

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New Worlds in Science. Edited by H. WARD. 670 pp. $3.50. 1941. McBride.

This is an anthology of contemporary science. The author has assembled a collection of writings that, in his opinion, reflect the ideas and describe the achievements of some of the most eminent scientists and research workers of our time.

Explorers of the Antarctic. W. H. HOBBS. Illustrated. 334 pp. $3.00. 1941. Field.

An Arctic explorer, student of polar regions and a personal acquaintance of nearly all polar explorers of modern times, tells the life histories of several of these celebrated men as one by one they met the challenge of new frontiers.

What Are Vitamins? W. H. EDDY. Illustrated. 247 pp. $2.75. January, 1941. Reinhold.

Two chapters on the nature and work of vitamins in general are followed by chapters devoted to individual vitamins: their sources, properties, functions and effects. The author attempts to condense already available information without sacrifice of accuracy.

Bacteriology of Public Health. G. M. CAMERON. Illustrated. 451 pp. 1940. Mosby.

This book presents information in regard to pathological bacteriology from the public health viewpoint, attempting to incorporate only those descriptions of symptoms and processes of diseases which are of definite value in understanding the infecting organisms.

The Plant Doctor. CYNTHIA WESTCOTT. Illustrated. xv + 297 pp. $2.00. 1941. Stokes.

A garden guide for the control of plant pests; based on the author's practical experience in garden maintenance. It offers special advice for gardeners in the Middle West, Southeast, Southwest and California, as well as the Eastern states.

The New Prometheus. L. BRYSON. 107 pp. $1.00. 1941. Macmillan.

A message to educators and laymen pressing the problem of teaching people to think, this book indicates the need to quicken the will to think and to employ the method of science in attempts to solve the problems of living in critical times.

Chemical Warfare. C. WACHTEL. lx + 312. $4.00. March, 1941. Chemical Publishing Co.

This book endeavors to present information on this specialized branch of applied science in a form comprehensible not only to chemists, physicians, engineers and military experts, but also to laymen who are perhaps potential victims of war gases.

The Golden Throng. E. W. TEALE. Illustrated. 208 pp. $3.00. 1941. Dodd, Mead.

An introductory chapter, tracing the bee's history and the evolution of the colony, is followed by the story of the life and individual duties of drone, queen and worker bees. Seventy-four photographs by the author of his own hive accompany the text.

The Adolescent Personality. P. BLOS. xiii + 517 pp. $3.00. 1941. Appleton-Century.

Four cases are selected of normal adolescent children of different socio-economic and educational levels. A theory of adolescent personality is developed in the first two cases and tested in the last two, finally applying this knowledge of adolescence to educational problems in general.

The Lungfish and the Unicorn. W. LEY. Illustrated. 305 pp. $2.75. April, 1941. Modern Age.

The author takes his reader on an "excursion into romantic zoology" as he answers questions and speculates concerning strange beasts from distant places and remote eras, gives accounts of scientific discovery, and attempts to view evolution as a continuous process.

Man, the Mechanical Misfit. G. H. EASTABROOKS. 251 pp. $2.50. March, 1941. Macmillan.

The author argues that as a result of not being fitted for modern civilization the individual as well as the race is degenerating; that science keeps our weaklings alive to propagate their weakness at the expense of the whole human race.

Living Treasure. I. T. SANDERSON. Illustrated. 290 pp. $3.50. 1941. Viking.

The author describes his work and adventures in Jamaica, British Honduras, Yucatan and the heights of Haiti, to study living animals in their natural surroundings. He was especially interested in correlating habitat to species, investigating disease among wild animals and plotting evolutionary graphs.

Help Your Doctor to Help You. Series W. C. ALVAREZ, editor. 95¢ each. 1941. Harper.

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